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EDUCATION AS A SCIENCE.

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II.

The Retentive Faculty.

THIS is the faculty that most of all concerns us in the work of education. On it rests the possibility of mental growths or capabilities not given by Nature.

Every impression made upon us, if sufficient to awaken consciousness at the time, has a certain permanence; it can persist after the original ceases to work; and it can be restored afterward as an idea or remembered impression. The bursting out of a flame arouses our attention, gives a strong visible impression, and becomes an idea or deposit of memory. It is thought of afterward without being actually seen.

It is not often that one single occurrence leaves a permanent and recoverable idea; usually, we need several repetitions for the purpose. The process of fixing the impression occupies a certain length of time; either we must prolong the first shock, or renew it on several successive occasions. This is the first law of memory, Retention or Acquisition: "Practice makes perfect;" "exercise is the means of strengthening a faculty," etc. The good old rule of the schoolmaster is simply to make the pupil repeat, rehearse, or persist at a lesson until it is learned.

All improvement in the art of teaching consists in having regard to the various circumstances that facilitate acquirement, or lessen the number of repetitions for a given effect. Much is possible in the way of economizing the plastic power of the human system; and when we have pushed this economy to the utmost, we have made perfect the Art of Education in one leading department. It is thus necessary

that the consideration of all the known conditions that favor or impede the plastic growth of the system should be searching and minute.

Although some philosophers have taught that all minds are nearly equal in regard to facility of acquirement, a schoolmaster that would say so must be of the very rudest type. The inequality of different minds in imbibing lessons, under the very same circumstances, is a glaring fact; and is one of the obstacles encountered in teaching numbers together, that is, classes. It is a difficulty that needs a great deal of practical tact or management, and is not met by any educational theory.

The different kinds of acquirements vary in minor circumstances which are important to be noticed after exhausting the general or pervading conditions. The greatest contrast is between what belongs to intelligence, and what belongs to the feelings and the will. The more strictly intellectual department comprises Mechanical Art, Language, the Sensible World, the Sciences, Fine Art; and to each of these heads may attach specialties not hard to assign.

General Circumstances favoring Retentiveness.—1. The physical condition. This has been already touched upon, both in the review of physiology, and in the remarks on discrimination. It includes general health, vigor and freshness at the moment, together with the further indispensable proviso that the nutrition, instead of being drafted off to strengthen the mere physical functions, is allowed to run in good measure to the brain.

In the view of mental efficiency, the muscular system, the digestive system, and the various organic interests, are to be exercised up to the point that conduces to the maximum of general vigor in the system, and no further. They may be carried further in the interest of sensual enjoyment, but that is not now before us. Hence a man must exercise his muscles, must feed himself liberally and give time to digestion to do its work, must rest adequately—all for the greatest energy of the mind, and for the trying work of education in particular. Nor is it so very difficult, in the present state of physiological and medical knowledge, to assign the reasonable proportions in all these matters, for a given case.

Everything tends to show that, in the mere physical point of view, the making of impressions on the brain, although never remitted during all our waking moments, is exceedingly unequal at different times. We must be well aware that there are moments when we are incapable of receiving any lasting impressions, and there are moments when we are unusually susceptible. The difference is not one wholly resolvable into mere mental energy on the whole; we may have a considerable reserve of force for other mental acts, as the performance of routine offices, and not much for retaining new impressions; we are capable of reading, talking, writing, and for taking an interest in the exer

cises; we may indulge emotions, and carry out pursuits, and yet not be in a state for storing the memory, or amassing knowledge. Even the incidents that we take part in sometimes fail to be remembered beyond a very short time.

What, then, is there so very remarkable and unique in the physical support of the plastic property of the brain? What are the moments when it is at the plenitude of its efficiency? What are the things that especially nourish and conserve it?

Although there is still wanting a careful study of this whole subject, the patent facts appear to justify us in asserting that the plastic or retentive function is the very highest energy of the brain, the consummation of nervous activity. To drive home a new experience, to make an impression self-sustaining and recoverable, uses up (we are to suppose) more brain-force than any other kind of mental exercise. The moments of susceptibility to the storing up of knowledge, the engraving of habits and acquisitions, are thus the moments of the maximum of unexpended force. The circumstances need to be such as to prepare the way for the highest manifestation of cerebral energy; including the perfect freshness of the system, and the absence of everything that would speedily impair it.

To illustrate this position, I may refer to the kind of mental work that appears to be second in its demand on the energy of the brain. The exercise of mental constructiveness—the solving of new problems, the applying of rules to new cases, the intellectual labor of the more arduous professions, as the law, where a certain amount of novelty attends every case that occurs—demands no little mental strain, and is easy according to the brain-vigor of the moment. Still, these are exercises that can be performed with lower degrees of power; we are capable of such professional work in moments when our memory would not take in new and lasting impressions. In old age, when we cease to be educable in any fresh endowment, we can still perform these constructive exercises; we can grapple with new questions, invent new arguments and illustrations, decide what should be done in original emergencies.

The constructive energy has all degrees, from the highest flights of invention and imagination down to the point where construction shades off into literal repetition of what has formerly been done. The preacher in composing a fresh discourse puts forth more or less of constructiveness; in repeating prayers and formularies, in reading from book, there is only reminiscence. This is the third and least exigent form of mental energy; it is possible in the very lowest states of cerebral vigor. When acquisition is fruitless, construction is possible; when a slight departure from the old routine passes the might of the intelligence, literal reminiscence may operate.

Another mode of mental energy that we are equal to, when the freshness of our susceptibility to new growths has gone off, is search-

ing and noting. This needs a certain strain of attention; it is not possible in the very lowest tide of the nervous flow; but it may be carried on with all but the smallest degrees of brain-power. When the scholar or the man of science ceases to trust his memory implicitly for retaining new facts that occur in his reading, observation, or reflection, he can still keep a watch for them, and enter them in his notes. So in the hours of the day when memory is less to be trusted, useful study may still be maintained by the help of the memorandum and the note-book.

The indulgence of the emotions (when not violent or excessive) is about the least expensive of our mental exercises, and may go on when we are unfit for any of the higher intellectual moods, least of all for the crowning work of storing up new knowledge or new aptitudes. There are degrees here also; but, speaking generally, to love or to hate, to dominate or to worship, although impossible in the lowest depths of debility, are within the scope of the inferior grades of nervous power.

From this estimate of comparative outlay, we may judge what are the times and seasons and circumstances most favorable to acquirement. It may be assumed that in the early part of the day the total energy of the system is at its height, and that toward evening it flags; hence morning is the season of improvement. For two or three hours after the first meal, the strength is probably at the highest; total remission for another hour or two, and a second meal (with physical exercise when the labor has been sedentary), prepares for a second display of vigor, although presumably not equal to the first; when the edge of this is worn off, there may, after a pause, be another bout of application, but far inferior in result to the first or even to the second. No severe strain should be attempted in this last stage; not much stress should be placed on the available plasticity of the system, although the constructive and routine efforts may still be kept up.

The regular course of the day may be interfered with by exceptional circumstances, but these only confirm the rule. If we have lain idle or inactive for the early hours, we may of course be fresher in the evening, but the late application will not make up for the loss of the early hours; the nervous energy will gradually subside as the day advances, however little exertion we may make. Again, we may at any time determine an outburst of nervous energy by persistent exercise and by stimulation, which draws blood to the brain, without regard to circumstances and seasons, but this is wasteful in itself and disturbing to the healthy functions.

As a general rule, the system is at its greatest vigor in the cold season of the year; and most work is done in winter. Summer studies are comparatively unproductive.

The review of the varying plasticity in the different stages of life might be conducted on the same plan of estimating the collective

forces of the system, and the share of these available for brain-work, but other circumstances have to be taken into the account, and I do not enter upon the question here.

There are many details in the economy of the plastic power that have a physical as well as a mental aspect. Such are those relating to the strain and remission of the attention, to the pauses and alternations during the times of drill, to the moderating of the nervous excitement, and other matters. These should all find a place under the head of the Retentive function. It is expedient now to take up the consideration of the subject from the purely mental side.

2. The one circumstance that sums up all the mental aids to plasticity is CONCENTRATION. A certain expenditure of nervous power is involved in every adhesion, every act of impressing the memory, every communicated bias; and the more the better. This supposes, however, that we should withdraw the forces, for the time, from every other competing exercise; and, especially, that we should redeem all wasting expenditure for the purpose in view.

It is requisite, therefore, that the circumstances leading to the concentration of the mind should be well understood. We assume that there is power available for the occasion, and we seek to turn it into the proper channel. Now, there is no doubt that the will is the chief intervening influence, and the chief stimulants of the will are, as we know, pleasure and pain. This is the rough view of the case. A little more precision is attainable through our psychological knowledge.

And first, the will itself as an operating or directing power, that is to say, the moving of the organs in a given way under a motive, is a growth or culture; it is very imperfect at first, and improves by usage. A child of twelve months cannot by any inducement be prompted readily to clap its hands, to point with its forefinger, to touch the tip of its nose, to move its left shoulder forward. The most elementary acts of the will, the alphabet of all the higher acquisitions, have first to be learned in a way of their own; and until they have attained a sufficient advancement, so as to be amenable to the spur of a motive, the teacher has nothing to go upon.

I have elsewhere described this early process, as I conceive it, in giving an account of the development of the will. In the practice of education, it is a matter of importance as showing at what time mechanical instruction is possible, and what impedes its progress at the outset, notwithstanding the abundance of plasticity in the brain itself. The disciplining of the organs to follow directions would seem to be the proper province of the infant school.

Coming now to the influences of concentration, we assign the first place to intrinsic charm, or *pleasure in the act* itself. The law of the will, in its side of greatest potency, is that pleasure sustains the movement that brings it. The whole force of the mind at the moment

goes with the pleasure-giving exercise. The harvest of immediate pleasure stimulates our most intense exertions, if exertion serves to prolong the blessing. So it is with the deepening of an impression, the confirming of a bent or bias, the associating of a couple or a sequence of acts; a coinciding burst of joy awakens the attention, and thus leads to an enduring stamp on the mental framework.

The ingraining efficiency of the pleasurable motive requires not only that we should not be carried off into an accustomed routine of voluntary activities, such as to give to the forces another direction, as when we pace to and fro in a flower-garden; but also that the pleasure should not be intense or tumultuous. The law of the mutual exclusion of great pleasure and great intellectual exertion forbids the employment of too much excitement of any kind, when we aim at the most exacting of all mental results — the forming of new adhesive growths. A gentle pleasure that for the time contents us, there being no great temptation at hand, is the best foster-mother of our efforts at learning. Still better, if it be a growing pleasure; a small beginning, with steady increase, never too absorbing, is the best of all stimulants to mental power. In order to have a yet wider compass of stimulation, without objectionable extremes, we might begin on the negative side, that is, in pain or privation, to be gradually remitted in the course of the studious exercise, giving place at last to the exhilaration of a waxing pleasure. All the great teachers, from Socrates downward, seem to recognize the necessity of putting the learner into a state of pain to begin with; a fact that we are by no means to exult over, although we may have to admit the stern truth that is in it. The influence of pain, however, takes a wider range than here supposed, as will be seen under our next head.

A moderate exhilaration and cheerfulness, growing out of the act of learning itself, is certainly the most genial, the most effectual means of cementing the unions that we desire to form in the mind. This is meant when we speak of the learner having a taste for his pursuit, having the *heart* in it, learning *con amore*. The fact is perfectly well known; the error, in connection with it, lies in dictating or enjoining this state of mind on everybody in every situation, as if it could be commanded by a wish, or as if it were not itself an expensive endowment. The brain cannot yield an exceptional pleasure without charging for it.

Next to pleasure in the actual, as a concentrating motive, is pleasure in *prospect*, as in learning what is to bring us some future gratification. The stimulus has the inferiority attaching to the idea of pleasure as compared with the reality. Still it may be of various degrees, and may rise to a considerable pitch of force. Parents often reward their children with coins for success in their lessons; the conception of the pleasure in this case is nearly equal to a present tremor of sense-delight. On the other hand, the promises of fortune and

distinction, after a long interval of years, have seldom much influence in concentrating the mind toward a particular study.

Let us now view the operation of pain. By the law of the will, pain repels us from the thing that causes it. A painful study repels us, just as an agreeable one attracts and detains us. The only way that pain can operate is when it is attached to neglect, or to the want of mental concentration in a given subject; we then find pleasure, by comparison, in sticking to our task. This is the theory of punishing the want of application. It is in every way inferior to the other motives; and this inferiority should be always kept in view in employing it, as every teacher often must with the generality of scholars. Pain is a waste of brain-power; while the work of the learner needs the very highest form of this power. Punishment works at a heavy percentage of deduction, which is still greater as it passes into the well-defined form of terror. Every one has experienced cases where severity has rendered a pupil utterly incapable of the work prescribed.

Discarding all *a priori* theories as to whether the human mind can be led on to study by an ingenious system of pleasurable attractions, we are safe in affirming that if the physical conditions are properly regarded, if the work is within the compass of the pupil's faculties, and if a fair amount of assistance is rendered in the way of intelligible direction, although some sort of pain will frequently be necessary, it ought not to be so great as to damp the spirits and waste the plastic energy.

The line of remark is exactly the same for pain in prospect, with allowance for the difference between reality and the idea. It is well when prospective pain has the power of a motive, because the future bad consequences of neglect are so various and so considerable as to save the resort to any other. But since the young mind in general is weak in the sense of futurity, whether for good or for evil, only very near, very intelligible, and very certain pains, can take the place of presently-acting deterrents.

In the study of the human mind, we need, for many purposes, to draw a subtile distinction between feeling as pleasure or pain, and feeling as excitement not necessarily pleasurable or painful. This subtilty cannot be dispensed with in our present subject. There is a form of mental concentration that is properly termed excitement, and is not properly termed pleasurable or painful excitement. A loud or sudden shock, a rapid whirling movement, stirs, wakens, or excites us; it may also give us pleasure or pain, but it may be perfectly neutral; and even when there is pleasure or pain, there is an influence apart from what would belong to pleasure or pain, as such. A state of excitement seizes hold of the mind for the time being and shuts out other mental occupations; we are engrossed with the subject that brought on the state, and are not amenable to extraneous influences, until that has subsided. Hence, excitement is preëminently a means

of making an impression, of stamping an idea in the mind; it is strictly an intellectual stimulus. There is still the proviso (under the general law of incompatibility of the two opposite moods) that the excitement must not be violent and wasting. In well-understood moderation, excitement is identical with attention, mental engrossment, the concentration of the forces upon the plastic or cementing operation, the rendering permanent as a recollection what lies in the focus of the blaze. Excitement, so defined, is worthless as an end, but is valuable as a means; and that means is the furtherance of our mental improvement by driving home some useful concatenation of ideas.

Another subtilty remains—a distinction within a distinction. After contrasting feeling as excitement with feeling as pleasure or pain, we must separate the useful from the useless or even pernicious modes of excitement. The useful excitement is what is narrowed and confined to the subject to be impressed; the useless, and worse than useless, excitement is what spreads far and wide, and embraces nothing in particular. It is easy to get up the last species of excitement—the vague, scattered, and tumultuous mode—but this is not of avail for any set purpose; it may be counted rather as a distracting agency than as a means of calling forth and concentrating the attention upon an exercise.

The true excitement for the purpose in view is what grows out of the very subject itself, surrounding and adhering to that subject. Now, for this kind of excitement, the recipe is continuous application of the mind in perfect surrounding stillness. Restrain all other solicitation of the senses; keep the attention upon the one act to be learned; and, by the law of nervous and mental persistence, the currents of the brain will become gradually stronger and stronger, until they have reached the point when they do no more good for the time. This is the ideal of concentration by neutral excitement.

The enemy of such happy neutrality is pleasure from without; and the youthful mind cannot resist the distraction of a present pleasure, or even the scent of a far-off pleasure. The schoolroom is purposely screened off from the view of what is going on outside; while all internal incidents that hold out pleasurable diversion are carefully restrained, at least during the crisis of a difficult lesson. A touch of pain, or apprehension, if *only slight*, is not unfavorable to the concentration.

A very important observation remains, namely, that relationship of retention to discrimination which was stated in introducing the function of discrimination. The consideration of this relationship illustrates with still greater point the true character of the excitement that concentrates and does not distract nor dissipate the energies. The moment of a delicate discrimination is the moment when the intellectual force is dominant; emotion spurns nice distinctions,

and incapacitates the mind for feeling them. The quiescence and stillness of the emotions enables the mind to give its full energies to the intellectual processes generally; and of these, the fundamental is perception of difference. Now, the more mental force we can throw into the act of noting a difference, the better is that difference felt, and *the better it is impressed.* The same act that favors discrimination favors retention. The two cannot be kept separate. No law of the intellect appears to be more certain than the law that connects our discriminating power with our retentive power. In whatever class of subjects our discrimination is great—colors, forms, tunes, tastes—in that class our retention is great. Whenever the attention can be concentrated on a subject in such a way as to make us feel all its delicate lineaments, which is another way of stating the sense of differences, through that very circumstance a great impression is made on the memory; there is no more favorable moment for engraving a recollection.

The perfection of neutral excitement, therefore, is typified by the intense rousing of the forces in an act or a series of acts of discrimination. If by any means we can succeed in this, we are sure that the other intellectual consequences will follow. It is a rare and difficult attainment in volatile years; the conditions, positive and negative, for its highest consummation cannot readily be commanded. Yet we should clearly comprehend what these conditions are; and the foregoing attempt has been made to seize and embody them.

Pleasure and pain, besides acting in their own character—that is, directing the voluntary actions, have a power as mere excitement, or as wakening up the mental blaze, during which all mental acts, including the impressing of the memory, are more effective. The distinction must still be drawn between concentrated and diffused excitement, between excitement *in*, and excitement *away from*, the work to be done. Pleasure is the most favorable adjunct, if not too great. Pain is the more stimulating or exciting; under a painful smart the forces are very rapidly quickened for all purposes, until we reach the point of wasteful dissipation. This brings us round again to the Socratic position, the preparing of the learner's mind by the torpedo or the gad-fly.

The full compass of the operation of the painful stimulant is well shown in some of our most familiar experiences as learners. In committing a lesson to memory, we con it a number of times by the book: we then try without the book. We fail utterly, and are slightly pained by the failure. We go back to the book, and try once more without it. We still fail, but strain the memory to recover the lost trains. The pains of failure and the act of straining stimulate the forces; the attention is aroused seriously and energetically. The next reference to the book finds us far more receptive of the impression to be made; the weak links are now reënforced with

avidity, and the next trial shows the value of the discipline that has been undergone.

One remark more will close the view of the conditions of plasticity. It is, that discrimination and retentiveness have a common support in rapidity and sharpness of transition. A sharp and sudden change is commonly said to make a strong *impression:* the fact implied concerns discrimination and retention alike. Vague, shadowy, ill-defined boundaries fail to be discriminated, and the subjects of them are not remembered. The educator finds great scope for his art in this consideration also.

FORMATION OF RAINDROPS AND HAILSTONES.[1]

WHEN the particles of water or ice which constitute a cloud or fog are all of the same size, and the air in which they are sustained is at rest or is moving uniformly in one direction, then these particles can have no motion relatively to each other. The weight of the particles will cause them to descend through the air with velocities which depend on their diameters, and, since they are all of the same size, they will all move with the same velocity.

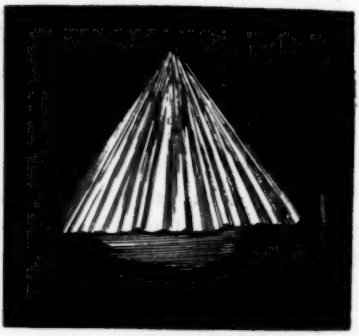

FIG. 1.—PERFECT HAILSTONE.

Under these circumstances, therefore, the particles will not traverse the spaces which separate them, and there can be no aggregation so as to form raindrops or hailstones.

If, however, from circumstances to be presently considered, some of the particles of the cloud or fog attain a larger size than others, these will descend faster than the others, and will consequently overtake those immediately beneath them; with these they may combine

[1] Abstract of paper "On the Manner in which Raindrops and Hailstones are formed," by Prof. Osborne Reynolds, M. A., read at the Literary and Philosophical Society, Manchester.

so as to form still larger particles which will move with greater velocity, and more quickly overtaking the particles in front of them will add to their size at an increasing rate.

Under such circumstances, therefore, the cloud would be converted into rain or hail according as the particles were water or ice.

The size of the drops from such a cloud would depend simply on the quantity of water suspended in the space swept through by the drop in its descent, that is to say, on the density and thickness of the cloud below the point from which the drops started.

The author's object is to suggest that this is the actual way in which raindrops and hailstones are formed. He was first led to this conclusion from observing closely the structure of ordinary hailstones. Although to the casual observer hailstones may appear to have no particular shape except that of more or less imperfect spheres, on closer inspection they are seen all to partake more or less of a conical

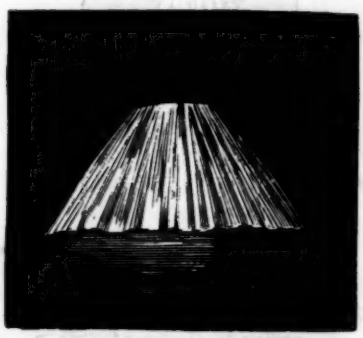

FIG. 2.—BROKEN HAILSTONE.

form with a rounded base like the sector of a sphere. In texture they have the appearance of an aggregation of minute particles of ice fitting closely together, but without any crystallization such as that seen in the snow-flake, although the surface of the cone is striated, the striæ radiating from the vertex. Such a form and texture as this is exactly what would result if the stones were formed in the manner described above. When a particle which ultimately formed the vertex of the cone started on its downward descent and encountered other particles on its lower face, they would adhere to it, however slightly. The mass, therefore, would grow in thickness downward; and as some of the particles would strike the face so close to the edge that they would overhang, the lower face would continually grow broader, and a conical form be given to the mass above.

When found on the ground the hailstones are generally imperfect; and besides such bruises as may be accounted for by the fall, many of them appear to have been imperfect before reaching the ground. Such deformities, however, may be easily accounted for. The larger stones fall faster than those which are smaller, and consequently may

overtake them in their descent; and then the smaller stones will stick to the larger and at once deform them. But besides the deformation caused by the presence of the smaller stone, the effect of the impact may be to impart a rotary motion to the stone, so that now it will no longer continue to grow in the same manner as before. Hence we have causes for almost any irregularities of form in the ordinary hailstone.

FIG. 3.—IMITATION IN PLASTER OF PARIS.

It appears, from the numerous accounts which have been published, that occasionally hailstones are found whose form is altogether different from that described above. These, however, are exceptional, and, to whatever causes they may owe their peculiarities, these causes cannot affect the stones to which reference is here made.

Again, on careful examination, it is seen that the ordinary hailstones are denser and firmer toward their bases or spherical sides than near the vertex of the cone, which latter often appears to have broken off in the descent. This, also, is exactly what would result from the manner of formation described above. When the particle first starts it will be moving slowly, and the force with which the particles impinge upon it will be slight, and consequently its texture loose; as, however, it grows in size and its velocity increases, it will strike the particles it overtakes with greater force and so drive them into a more compact mass. If the velocity were sufficient, the particles would strike with sufficient force to adhere as solid ice, and this appears to be the case when the stones become large, as large as a walnut, for instance.

An idea of the effect of the suspended particles, on being overtaken

by the stone, may be formed from the action of the particles of sand in Mr. Tilghman's sand-blast, used for cutting glass. The two cases are essentially the same, the only difference being that the hailstone is moving through the air, whereas, in the case of the sand-blast, the object which corresponds to the stone is fixed, and the sand is blown against it.

By this sand-blast the finest particles of sand are made to indent the hardest material, such as quartz or hard steel; so that the actual intensity of the pressure between the surface of the particles of sand and that of the object they strike must be enormous. And yet the velocity of the blast is not so much greater than that at which a good-sized hailstone descends. It is easy to conceive, therefore, that the force of the impact of the suspended particles of ice, if not much below the temperature of freezing, on a large hailstone, would drive them together so as to form solid ice. For the effect of squeezing two particles of ice together is to cause them to thaw at the surface of contact, and as soon as the pressure is relieved they freeze again, and hence their adhesion.

It is then shown that hailstones, such as those described, can neither be formed by the freezing of raindrops, nor by the condensation of vapor on a nucleus of ice; and that it is impossible that the particles of ice can have been drawn together by electrical attraction

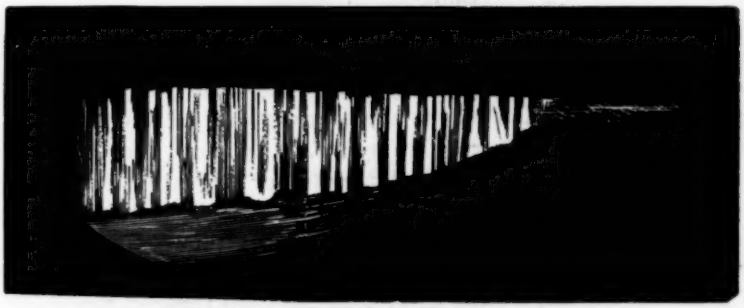

FIG. 4.—IMITATION IN PLASTER OF PARIS.

—their conical shape, and the increase in their density toward their thicker sides, clearly showing that the particles have aggregated from one direction, and with an increasing force as the size of the stone has increased.

The possibility of making artificial stones is thus considered: If a stream of frozen fog were driven against any small object, then the frozen particles should accumulate on the object in a mass resembling a hailstone. Not seeing his way to obtain such a stream of frozen fog, the author thought it might be worth while to try the effect of blowing very finely-powdered plaster of Paris. He therefore introduced a stream of this material into a jet of steam, issuing freely into

the air (which he hoped would moisten the powdered plaster sufficiently to cause it to set firmly into whatever form it collected). The jet was directed against a splinter of wood.

In this way masses of plaster very closely resembling hailstones were obtained. They were all more or less conical, with their bases facing the jet. But, as might be expected, the angles of the cones were all smaller than those of the hailstones. Two of these figures are shown in the sketches annexed.

The striæ were strongly marked, and exactly resembled those of the hailstone. The bases also were rounded. They were somewhat steeper than those of the hailstone; but this was clearly due to the want of sufficient cohesive power on the part of the plaster. It was not sufficiently wet. Owing to this cause also it was not possible to preserve the lumps when they were formed, as the least shake caused them to tumble in pieces.

Similar masses were also obtained by blowing the vapor of naphthaline, but these were also very fragile. Whereupon it is remarked: At ordinary temperatures the powdered naphthaline does not adhere like ice when pressed into a lump. No doubt at very low temperatures ice would behave in the same way, that is to say, the particles would not adhere from the force of impact. Hence it would seem probable that, for hailstones to be formed, the temperature of the cloud must not be much below the freezing-point.

That the effect of the temperature of the cloud exercises great influence on the character of the hailstones cannot be doubted. And if, as has been suggested by M. L. Dufour, the particles will sometimes remain fluid, even when the temperature is as low as 0° Fahr., it is clear that, as they are swept up by a falling stone, they may freeze into homogeneous ice either in a laminated or crystalline form.

The author then proceeds to show that raindrops are probably formed in the same way as hailstones; that, although the raindrops have no structural peculiarities like the hailstones, the aggregation of the particles of water by the descent of the drop through the cloud is the only explanation which will account for them. He shows that, as Mr. Baxendell had previously pointed out, the amount of vapor which a cold drop could condense before it becomes as warm as the vapor would be inappreciable when compared with the size of the drop; and since, in order that there might be condensation, the air must be warmer than the drop, the drop could not part with its heat to the air. He also shows that during the time of descent of a large drop the heat lost by radiation would not account for the condensation of sufficient vapor to make any appreciable difference in the size of the drop. Whereas, if we suppose all the vapor which a body of saturated air at 60° Fahr. would contain over and above what it would contain at 32° to be changed into a fog or cloud, then if a particle, after commencing to descend, aggregated to itself all the water suspended

in the volume of air through which it swept, the diameter of the drop after passing through 2,000 feet would be more than an eighth of an inch, and after passing through 4,000 feet a quarter of an inch, and so on. So that, in passing through 8,000 feet of such cloud, it would acquire a diameter of half an inch.

The fact that raindrops never attain the size of large hailstones is explained as being due to the mobility in the case of large drops of the surface tension of the water, by which alone the drop retains its form, to withstand the disturbing force of the air rushing past; when the drop reaches a certain size, therefore, it is blown in pieces like the water from a fountain.

The origin of stones and drops is then discussed—why some of the particles in a cloud should be larger than the others, as it is necessary for them to be in order that they may commence a more rapid descent. A cloud does not always rain; and hence it would seem that in their normal condition the particles of a cloud are all of the same size and have no internal motion, and that the variation of size is due to some irregularity or disturbance in the cloud.

Such irregularity would result when a cloud is cooling by radiation from its upper surface. The particles on the top of the cloud being more exposed would radiate faster than those below them, and hence they would condense more vapor and grow more rapidly in size. They would therefore descend and leave other particles to form the top of the cloud. In this way we should have in embryo a continuous succession of drops.

Eddies in the cloud also form another possible cause of the origin of drops and stones.—*Nature.*

ON THE STUDY OF BIOLOGY.[1]

By Professor T. H. HUXLEY.

IT is my duty to-night to speak about the study of biology, and while it may be that there are many among you who are quite familiar with that study, yet, as a lecturer of some standing, it would, I know by experience, be very bad policy on my part to suppose such to be extensively the case. On the contrary, I must imagine that there are many of you who would like to know what biology is; that there will be others who have that amount of information, but would nevertheless gladly learn why it should be worth their while to study biology; and yet others, again, to whom these two points are clear, but who desire to learn how they had best study it, and, finally, when

[1] A lecture by Prof. Huxley, delivered at the South Kensington Museum, on Saturday, December 16, 1876.

they had best study it; and I shall address myself to the endeavor to give you some answer to these four questions—what biology is; why it should be studied; how it should be studied; and when it should be studied.

In the first place, in respect to what biology is, there are, I believe, some persons who imagine that the term "biology" is simply a new-fangled denomination, a neologism, in short, for what used to be known under the title of "natural history;" but I shall try to show you, on the contrary, that the word is the expression of the growth of science during the last two hundred years, and came into existence half a century ago.

At the revival of learning, knowledge was divided into two kinds —the knowledge of Nature, and the knowledge of man; for it was the current idea then (and a great deal of that ancient conception still remains) that there was a sort of essential antithesis, not to say antagonism, between Nature and man; and that the two had not very much to do with one another, except that the one was oftentimes exceedingly troublesome to the other. Though it is one of the salient merits of our great philosophers of the seventeenth century that they recognize but one scientific method, applicable alike to man and to Nature, we find this notion of the existence of a broad distinction between Nature and man in the writings of Bacon and Hobbes of Malmesbury; and I have brought with me that famous work which is now so little known, greatly as it deserves to be studied, "The Leviathan," in order that I may put to you, in the wonderfully terse and clear language of Thomas Hobbes, what was his view of the matter. He says:

"The register of knowledge of fact is called history. Whereof there be two sorts: one called natural history; which is the history of such facts or effects of Nature as have no dependence on man's will; such as are the histories of metals, plants, animals, regions, and the like. The other is civil history; which is the history of the voluntary actions of men in commonwealths."

So that all history of fact was divided into these two great groups of natural and of civil history. The Royal Society was in course of foundation about the time that Hobbes was writing this book, which was published in 1651, and that Society is termed a "Society for the Advancement of Natural Knowledge," which is nearly the same thing as a "Society for the Advancement of Natural History." As time went on, and the various branches of human knowledge became more distinctly developed and separated from one another, it was found that some were much more susceptible of precise mathematical treatment than others. The publication of the "Principia" of Newton, which probably gave a greater stimulus to physical science than any work ever published before, or which is likely to be published hereafter, showed that precise mathematical methods were applicable to

those branches of science, such as astronomy, and what we now call physics, which occupy a very large portion of the domain of what the older writers understood by natural history. And inasmuch as the partly deductive and partly experimental methods of treatment, to which Newton and others subjected these branches of human knowledge, showed that the phenomena of Nature which belonged to them were susceptible of explanation, and thereby came within the reach of what was called "philosophy" in those days, so much of this kind of knowledge as was not included under astronomy came to be spoken of as "natural philosophy"—a term which Bacon had employed in a much wider sense. Time went on, and yet other branches of science developed themselves. Chemistry took a definite shape, and as all these sciences, such as astronomy, natural philosophy, and chemistry, were susceptible either of mathematical treatment or of experimental treatment, or of both, a great distinction was drawn between the experimental branches of what had previously been called natural history and the observational branches—those in which experiment was (or appeared to be) of doubtful use, and where, at that time, mathematical methods were inapplicable. Under these circumstances the old name of "natural history" stuck by the residuum, by those phenomena which were not, at that time, susceptible of mathematical or experimental treatment; that is to say, those phenomena of Nature which come now under the general heads of physical geography, geology, mineralogy, the history of plants, and the history of animals. It was in this sense that the term was understood by the great writers of the middle of the last century—Buffon and Linnæus—by Buffon in his great work, the "Histoire Naturelle Générale," and by Linnæus in his splendid achievement, the "Systema Naturæ." The subjects they deal with are spoken of as "natural history," and they called themselves, and were called, naturalists. But you will observe that this was not the original meaning of these terms; but that they had, by this time, acquired a signification widely different from that which they possessed primitively.

The sense in which "natural history" was used at the time I am now speaking of has, to a certain extent, endured to the present day. There are now in existence, in some of our northern universities, chairs of Civil and Natural History, in which the term "natural history" is used to indicate exactly what Hobbes and Bacon meant by that term. There are others in which the unhappy incumbent of the chair of Natural History is, or was, still supposed to cover the whole ground of geology and mineralogy, zoölogy, perhaps even botany, in his lectures. But as science made the marvelous progress which it did make at the end of the last and the beginning of the present century, thinking men began to discern that under this title of "natural history" there were included very heterogeneous constituents—that, for example, geology and mineralogy were, in many respects, very

different from botany and zoölogy; that a man might obtain an extensive knowledge of the structure and functions of plants and animals, without having need to enter upon the study of geology and mineralogy, and *vice versa;* and, further, as knowledge advanced, it became clear that there was a great analogy, a very close alliance, between those two sciences of botany and zoölogy which deal with living beings, while they are much more widely separated from all other studies. It is due to Buffon to remark that he clearly recognized this great fact. He says: "Ces deux genres d'êtres organisés (les animaux et les végétaux) ont beaucoup plus de propriétés communes que de différences réelles." Therefore it is not wonderful that at the beginning of the present century, and oddly enough in two different countries, and, so far as I know, without any intercommunication between the respective writers, two famous men clearly conceived the notion of uniting the whole of the sciences which deal with living matter into one whole, and of dealing with them as one discipline. In fact, I may say there were three men to whom this idea occurred contemporaneously, although there were but two who carried it into effect, and only one who worked it out completely. The persons to whom I refer were the eminent physiologist Bichat,[1] the great naturalist Lamarck, in France; and a distinguished German, Treviranus. Bichat assumed the existence of a special group of "physiological" sciences. Lamarck, in a work published in 1801,[2] for the first time made use of the name "biologie," from the two Greek words which signify a *discourse upon life and living things.* About the same time it occurred to Treviranus that all those sciences which deal with living matter are essentially and fundamentally one, and ought to be treated as a whole, and in the year 1802 he published the first volume of what he also called "Biologie." Treviranus's great merit consists in this, that he worked out his idea, and that he published the very remarkable book to which I refer, which consists of six volumes, and which occupied him for twenty years—from 1802 to 1822.

That is the origin of the term "biology," and that is how it has come about that all clear thinkers and lovers of consistent nomenclature have substituted for the old confusing name of "natural history," which has conveyed so many meanings, the term "biology" to denote the whole of the sciences which deal with living things, whether they be animals or whether they be plants. Some little time ago—in the course of this year, I think—I was favored by a learned classic, Dr. Field, of Norwich, with a disquisition, in which he endeavored to prove that from a philological point of view neither Treviranus nor Lamarck had any right to coin this new word "biology" for his

[1] *See* the distinction between the "sciences physiques" and the "sciences physiologiques" in the "Anatomie Générale," 1801.

[2] "Hydrogéologie," an. x. (1801).

purpose; that, in fact, the Greek word "bios" had relation only to human life and human affairs, and that a different word was employed when they wished to speak of the life of animals and plants. So Dr. Field tells us we are all wrong in using the term biology, and that we ought to employ another—only, unluckily, he is not quite sure about the propriety of that which he proposes as a substitute. It is a somewhat hard one—zoötocology. I am sorry we are wrong, because we are likely to continue so. In these matters we must have some sort of "statute of limitations." When a name has been employed for half a century, persons of authority [1] have been using it, and its sense has become well understood, I am afraid that people will go on using it, whatever the weight of philological objection.

Now that we have arrived at the origin of this word "biology," the next point to consider is, What ground does it cover? I have said that in its strict technical sense it covers all the phenomena that are exhibited by living things, as distinguished from those which are not living; but while that is all very well so long as we confine ourselves to the lower animals and to plants, it lands us in a very considerable difficulty when we reach the higher forms of living things. For, whatever view we may entertain about the nature of man, one thing is perfectly certain, that he is a living creature. Hence, if our definition is to be interpreted strictly, we must include man and all his ways and works under the head of biology; in which case we should find that psychology, politics, and political economy, would all be absorbed into the province of biology. In fact, civil history would be merged in natural history. In strict logic it may be hard to object to this course, because no one can doubt that the rudiments and outlines of our own mental phenomena are traceable among the lower animals. They have their economy and their polity; and if, as is always admitted, the polity of bees and the commonwealth of wolves fall within the purview of the biologist proper, it becomes hard to say why we should not include therein human affairs, which in so many cases resemble those of bees in zealous getting, and are not without a certain parity in the proceedings of wolves. The real fact is, that we biologists are a self-sacrificing people; and inasmuch as, on a moderate estimate, there are about a quarter of a million different species of animals and plants to know about already, we feel that we have more than sufficient territory. There has been a sort of practical convention by which we give up to a different branch of science what Bacon and Hobbes would have called "civil history." That branch of science has constituted itself under the head of sociology. I may use phraseology which at present will be well understood, and say that we have allowed that province of biology to become autono-

[1] "The term *biology*, which means exactly what we wish to express, *the science of life*, has often been used and has of late become not uncommon among good writers." —Whewell, "Philosophy of the Inductive Sciences," vol. i., p. 544 (edition of 1847).

mous; but I should like you to recollect that that is a sacrifice, and that you should not be surprised if it occasionally happens that you see a biologist trespassing upon questions of philosophy or politics, or meddling with human education, because, after all, that is a part of his kingdom which he has only voluntarily forsaken.

Having now defined the meaning of the word "biology," and having indicated the general scope of biological science, I turn to my second question, which is, Why should we study biology? Possibly the time may come when that will seem a very odd question. That we, living creatures, should not feel a certain amount of interest in what it is that constitutes our life, will eventually, under altered ideas of the fittest objects of human inquiry, seem to be a singular phenomenon; but at present, judging by the practice of teachers and educators, this would seem to be a matter that does not concern us at all. I propose to put before you a few considerations which I dare say many of you will be familiar with already, but which will suffice to show—not fully, because to demonstrate this point fully would take a great many lectures—that there are some very good and substantial reasons why it may be advisable that we should know something about this branch of human learning. I myself entirely agree with another sentiment of the philosopher of Malmesbury, that "the scope of all speculation is the performance of some action or thing to be done," and I have not any very great respect for or interest in mere knowing as such. I judge of the value of human pursuits by their bearing upon human interests—in other words, by their utility; but I should like that we should quite clearly understand what it is that we mean by this word "utility." Now, in an Englishman's mouth, it generally means that by which we get pudding or praise, or both. I have no doubt that is one meaning of the word utility, but it by no means includes all I mean by utility. I think that knowledge of every kind is useful in proportion as it tends to give people right ideas, which are essential to the foundation of right practice, and to remove wrong ideas, which are the no less essential foundations and fertile mothers of every description of error in practice. And, upon the whole, inasmuch as this world is, after all, whatever practical people may say, absolutely governed by ideas, and very often by the wildest and most hypothetical ideas, it is a matter of the very greatest importance that our theories of things, and even of things that seem a long way apart from our daily lives, should be as far as possible true, and as far as possible removed from error. It is not only in the coarser practical sense of the word "utility," but in this higher and broader sense, that I measure the value of the study of biology by its utility, and I shall try to point out to you that you will feel the need of some knowledge of biology at a great many turns of this present nineteenth-century life of ours. For example, most of us lay great and very just stress upon the conception which is entertained

of the position of man in this universe, and his relation to the rest of Nature. We have almost all of us been told, and most of us hold by the tradition, that man occupies an isolated and peculiar position in Nature; that though he is in the world he is not of the world; that his relations to things about him are of a remote character, that his origin is recent, his duration likely to be short, and that he is the great central figure round which other things in this world revolve. But this is not what the biologists tell us. At the present moment you will be kind enough to separate me from them, because it is in no way essential to my argument just now that I should advocate their views. Don't suppose that I am saying this for the purpose of escaping the responsibility of their beliefs, because at other times and in other places I do not think that point has been left doubtful; but I want clearly to point out to you that for my present argument they may all be wrong; nevertheless, my argument will hold good. The biologists tell us that all this is an entire mistake. They turn to the physical organization of man. They examine his whole structure, his bony frame, and all that clothes it. They resolve him into the finest particles into which the microscope will enable them to break him up. They consider the performance of his various functions and activities, and they look at the manner in which he occurs on the surface of the world. Then they turn to other animals, and, taking the first handy domestic animal—say a dog—they profess to be able to demonstrate that the analysis of the dog leads them in gross to precisely the same results as the analysis of the man; that they find almost identically the same bones, having the same relations; that they can name the muscles of the dog by the names of the muscles of the man, and the nerves of the dog by those of the nerves of the man, and that such structures and organs of sense as we find in the man such also we find in the dog; they analyze the brain and spinal cord, and find the nomenclature which does for the one answer for the other. They carry their microscopic inquiries in the case of the dog as far as they can, and they find that his body is resolvable into the same elements as those of the man. Moreover, they trace back the dog's and the man's development, and they find that at a certain stage of their existence the two creatures are not distinguishable the one from the other; they find that the dog and his kind have a certain distribution over the surface of the world comparable in its way to the distribution of the human species. What is true of the dog they tell us is true of all the higher animals; and they find that for the whole of these creatures they can lay down a common plan, and regard the man and the dog, the horse and the ox, as minor modifications of one great fundamental unity. Moreover, the investigations of the last three-quarters of a century have proved, they tell us, that similar inquiries carried out through all the different kinds of animals which are met with in Nature will lead us, not in one straight series, but by many roads,

step by step, gradation by gradation, from man at the summit to specks of animated jelly at the bottom of the series; so that the idea of Leibnitz and of Bonnet that animals form a great scale of being in which there is a series of gradations from the most complicated form to the lowest and simplest—that idea, though not exactly in the form in which it was propounded by those philosophers, turns out to be substantially correct. More than this, when biologists pursue their investigations into the vegetable world, they find that they can in the same way follow out the structure of the plant from the most gigantic and complicated trees through a similar series of gradations until they arrive at similar specks of animated jelly, which they are puzzled to distinguish from those which they reached by the animal road.

Thus they have arrived at the conclusion that a fundamental uniformity of structure pervades the animal and vegetable worlds, and that plants and animals differ from one another simply as modifications of the same great general plan.

Again, they tell us the same story in regard to the study of function. They admit the large and important interval which, at the present time, separates the manifestations of the mental faculties observable in the higher forms of mankind, and even in the lower forms, such as we know them, mentally from those exhibited by other animals; but, at the same time, they tell us that the foundations or rudiments of almost all the faculties of man are to be met with in the lower animals; that there is a unity of mental faculty as well as of bodily structure, and that here also the difference is a difference of degree and not of kind. I said "almost all" for a reason. Among the many distinctions which have been drawn between the lower creatures and ourselves, there is one which is hardly ever insisted on,[1] but which may be fitly spoken of in a place so largely devoted to art as that in which we are assembled. It is this, that, while among various kinds of animals it is possible to discover traces of all the other faculties of man, especially the faculty of mimicry, yet that particular form of mimicry which shows itself in the imitation of form, either by modeling or by drawing, is not to be met with. As far as I know, there is no sculpture or modeling, and decidedly no painting or drawing, of animal origin. I mention the fact in order that such comfort may be derived therefrom as artists may feel inclined to take.

If what the biologists tell us is true, it will be needful for us to get rid of our erroneous conceptions of man and of his place in Nature, and substitute for them right ones. But it is impossible to form any judgment as to whether the biologists are right or wrong unless we are able to appreciate the nature of the arguments which they have to offer.

One would almost think that this was a self-evident proposition. I

[1] I think that Prof. Allman was the first to draw attention to it.

wonder what a scholar would say to the man who should undertake to criticise a difficult passage in a Greek play, but who obviously had not acquainted himself with the rudiments of the Greek grammar. And, before giving a positive opinion about these high questions of biology, people not only don't seem to think it necessary to be acquainted with the grammar of the subject, but they have not even mastered the alphabet. You find criticism and denunciation showered about by persons who not only have not attempted to go through the discipline necessary to enable them to be judges, but have not even reached that stage of emergence from ignorance in which the knowledge that such a discipline is necessary dawns upon the mind. I have had to watch with some attention—in fact, I have been favored with a good deal of it myself—the sort of criticism with which biologists and biological doctrines are visited. I am told every now and then that there is a "brilliant article"[1] in so-and-so, in which we are all demolished. I used to read these things once, but I am getting old, and I have ceased to attend very much to this cry of "wolf!" When one does read one of these productions, what one finds generally, on the face of it, is, that the brilliant critic is devoid of even the elements of knowledge in the matter, and that his brilliancy is like the light given out by the crackling of thorns under a pot of which Solomon speaks. So far as I recollect, Solomon makes use of that image for purposes of comparison; but I won't proceed into that matter further.

Two things must be obvious: in the first place, that every man who has the interests of truth at heart must earnestly desire that every well-founded and just criticism that can be made should be made; but it is essential to anybody's being able to benefit by criticism that the critic should know what he is talking about and be in a position to form a mental image of the facts symbolized by the word he uses. If not, it is as obvious in the case of a biological argument as it is in that of an historical or philological discussion, that such criticism is a mere waste of time on the part of the author, and wholly undeserving of attention on the part of those who are criticised. Take it, then, as an illustration of the importance of biological study that thereby alone are men able to form something like a rational conception of what constitutes valuable criticism of the teachings of biologists.[2]

[1] Galileo was troubled by a sort of people whom he called "paper-philosophers," because they fancied that the true reading of Nature was to be detected by the collation of texts. The race is not extinct, but, as of old, brings forth its "winds of doctrine" by which the weathercock-heads among us are much exercised.

[2] Some critics do not even take the trouble to read. I have recently been adjured with much solemnity to state publicly why I have "changed" my opinion as to the value of the paleontological evidence of the occurrence of evolution.

To this my reply is, Why should I, when that statement was made seven years ago? An address delivered from the presidential chair of the Geological Society in 1870 may

Next, I may mention another bearing of biological knowledge—a more practical one in the ordinary sense of the word. Consider the theory of infectious disease. Surely that is of interest to all of us. Now, the theory of infectious disease is rapidly being elucidated by biological study. It is possible to produce from among the lower animals cases of devastating diseases which have all the appearance of our infectious diseases, and which are certainly and unmistakably caused by living organisms. This fact renders it possible, at any rate, that that doctrine of the causation of infectious disease which is known under the name of "the germ-theory" may be well-founded; and, if so, it must needs lead to the most important practical measures in dealing with those most terrible visitations. It may be well that the general as well as the professional public should have a sufficient knowledge of biological truths to be able to take a rational interest in the discussion of such problems, and to see, what I think they may hope to see, that to those who possess a sufficient elementary knowledge of biology they are not all quite open questions.

Let me mention another important practical illustration of the value of biological study. Within the last forty years the theory of agriculture has been revolutionized. The researches of Liebig, and those of our own Lawes and Gilbert, have had a bearing upon that branch of industry, the importance of which cannot be over-estimated; but the whole of these new views have grown out of the better explanation of certain processes which go on in plants, and which, of course, form a part of the subject-matter of biology.

I might go on multiplying these examples, but I see that the clock won't wait for me, and I must, therefore, pass to the third question to which I referred: Granted that biology is something worth studying, what is the best way of studying it? Here I must point out that, since biology is a physical science, the method of studying it must needs be analogous to that which is followed in the other physical sciences. It has now long been recognized that if a man wishes to be a chemist it is not only necessary that he should read chemical books and attend chemical lectures, but that he should actually himself perform the fundamental experiments in the laboratory, and know exactly what the words which he finds in his books and hears from his teach-

be said to be a public document, inasmuch as it not only appeared in the journal of that learned body, but was republished in 1873 in a volume of "Critiques and Addresses," to which my name is attached. Therein will be found a pretty full statement of my reasons for enunciating two propositions: 1. That, "when we turn to the higher *Vertebrata*, the results of recent investigations, however we may sift and criticise them, seem to me to leave a clear balance in favor of the evolution of living forms one from another;" and 2. That the case of the horse is one which "will stand rigorous criticism."

Thus I do not see clearly in what way I can be said to have changed my opinion, except in the way of intensifying it, when in consequence of the accumulation of similar evidence since 1870 I recently spoke of the denial of evolution as not worth serious consideration.

ers, mean. If he does not do that, he may read till the crack of doom, but he will never know much about chemistry. That is what every chemist will tell you, and the physicist will do the same for his branch of science. The great changes and improvements in physical and chemical scientific education which have taken place of late have all resulted from the combination of practical teaching with the reading of books and with the hearing of lectures. The same thing is true in biology. Nobody will ever know anything about biology, except in a dilettant "paper-philosopher" way, who contents himself with reading books on botany, zoölogy, and the like; and the reason of this is simple and easy to understand. It is, that all language is merely symbolical of the things of which it treats; the more complicated the things, the more bare is the symbol, and the more its verbal definition requires to be supplemented by the information derived directly from the handling, and the seeing, and the touching of the thing symbolized: that is really what is at the bottom of the whole matter. It is plain common-sense, as all truth in the long-run is, only common sense clarified. If you want a man to be a tea-merchant, you don't tell him to read books about China or about tea, but you put him into a tea-merchant's office, where he has the handling, the smelling, and the tasting of tea. Without the sort of knowledge which can be gained only in this practical way, his exploits as a tea-merchant will soon come to a bankrupt termination. The "paper-philosophers" are under the delusion that physical science can be mastered as literary accomplishments are acquired, but unfortunately it is not so. You may read any quantity of books, and you may be almost as ignorant as you were at starting, if you don't have, at the back of your minds, the change for words in definite images which can only be acquired through the operation of your observing faculties on the phenomena of Nature.

It may be said: "That is all very well, but you told us just now that there are probably something like a quarter of a million different kinds of living and extinct animals and plants, and a human life could not suffice for the examination of one-fiftieth part of all this." That is true, but then comes the great convenience of the way things are arranged; which is, that, although there are these immense numbers of different kinds of living things in existence, yet they are built up, after all, upon marvelously few plans.

There are, I suppose, about 100,000 species of insects, if not more, and yet anybody who knows one insect—if a properly-chosen one—will be able to have a very fair conception of the structure of the whole. I do not mean to say he will know that structure thoroughly, or as well as it is desirable he should know it, but he will have enough real knowledge to enable him to understand what he reads, to have genuine images in his mind of those structures which become so variously modified in all the forms of insects he has not seen. In fact,

there are such things as types of form among animals and vegetables, and for the purpose of getting a definite knowledge of what constitutes the leading modifications of animal and plant life it is not needful to examine more than a comparatively small number of animals and plants.

Let me tell you what we do in the biological laboratory in the building adjacent to this. There I lecture to a class of students daily for about four and a half months, and my class have, of course, their text-books; but the essential part of the whole teaching, and that which I regard as really the most important part of it, is a laboratory for practical work, which is simply a room with all the materials arranged for ordinary dissection. We have tables properly arranged in regard to light, microscopes, and dissecting-instruments, and we work through the structure of a certain number of animals and plants. As, for example, among the plants we take a yeast-plant, a *Protococcus*, a common mould, a *Chara*, a fern, and some flowering plant; among the animals, we examine such things as an amœba, a *Vorticella*, and a fresh-water polyp. We dissect a star-fish, an earth-worm, a snail, a squid, and a fresh-water mussel. We examine a lobster and a craw-fish, and a black-beetle. We go on to a common skate, a codfish, a frog, a tortoise, a pigeon, and a rabbit, and that takes us about all the time we have to give. The purpose of this course is not to make skilled dissectors, but to give every student a clear and definite conception, by means of sense-images, of the characteristic structure of each of the leading modifications of the animal kingdom; and that is perfectly possible, by going no further than the length of that list of forms which I have enumerated. If a man knows the structure of the animals I have mentioned, he has a clear and exact, however limited, apprehension of the essential features of the organization of all those great divisions of the animal and vegetable kingdoms to which the forms I have mentioned severally belong. And it then becomes possible for him to read with profit, because, every time he meets with the name of a structure, he has a definite image in his mind of what the name means in the particular creature he is reading about, and therefore the reading is not mere reading. It is not mere repetition of words; but every term employed in the description, we will say, of a horse or of an elephant, will call up the image of the things he had seen in the rabbit, and he is able to form a distinct conception of that which he has not seen as a modification of that which he has seen.

I find this system to yield excellent results, and I have no hesitation whatever in saying that any one who has gone through such a course attentively is in a better posifion to form a conception of the great truths of biology, especially of morphology (which is what we chiefly deal with), than if he had merely read all the books on that topic put together.

The connection of this discourse with the Loan Collection of Scientific Apparatus arises out of the exhibition in that collection of aids to our laboratory-work. Such of you as have visited that very interesting collection may have noticed a series of diagrams and of preparations illustrating the structure of a frog. Those diagrams and preparations have been made for the use of the students in the biological laboratory. Similar diagrams and preparations, illustrating the structure of all the other forms of life we examine, are either made or in course of preparation. Thus the student has before him, first, a picture of the structure he ought to see; secondly, the structure itself worked out; and if, with these aids, and such needful explanations and practical hints as a demonstrator can supply, he cannot make out the facts for himself in the materials supplied to him, he had better take to some other pursuit than that of biological science.

I should have been glad to have said a few words about the use of museums in the study of biology, but I see that my time is becoming short, and I have yet another question to answer. Nevertheless, I must, at the risk of wearying you, say a word or two upon that important subject of museums. Without doubt, there are no helps to the study of biology, or rather to some branches of it, which are, or may be, more important than natural-history museums; but, in order to take this place in regard to biology, they must be museums of the future. The museums of the present do not do by any means so much for us as they might do. I do not wish to particularize, but I dare say many of you seeking knowledge, or in the laudable desire to employ a holiday usefully, have visited some great natural-history museum. You have walked through a quarter of a mile of animals well stuffed, with their long names written out underneath them; and, unless your experience is very different from that of most people, the upshot of it all is that you leave that splendid pile with sore feet, a bad headache, and a general idea that the animal kingdom is a mighty maze without a plan. I do not think that a museum which brings about this result has done all that may reasonably be expected of such an institution. What is needed in a collection of natural history is, that it should be made as accessible and as useful as possible on the one hand to the general public, and on the other to scientific workers. That need is not met by constructing a sort of happy hunting-ground of miles of glass cases, and, under the pretense of exhibiting everything, putting the maximum amount of obstacles in the way of those who wish properly to see anything.

What the public want is easy and unhindered access to such a collection as they can understand and appreciate; and what the men of science want is similar access to the materials of science. To this end the vast mass of objects of natural history should be divided into two parts—one open to the public, the other to men of science, every day, and all day long. The former division should exemplify all the more

important and interesting forms of life. Explanatory tablets should be attached to them, and catalogues, containing clearly-written expositions of the general significance of the objects exhibited, should be provided. The latter division should contain, packed into a comparatively small space, the objects of purely scientific interest. For example, we will say I am an ornithologist. I go to see a collection of birds. It is a positive nuisance to have them stuffed. It is not only sheer waste, but I have to reckon with the ideas of the bird-stuffer, while, if I have the skin, and nobody has interfered with it, I can form my own judgment as to what the bird was like. For ornithological purposes, what is needed is not glass cases full of stuffed birds on perches, but convenient drawers, into each of which a great quantity of skins will go. They occupy no great space, and do not require any expenditure beyond their original cost. But, for the purpose of the public, who want to learn, indeed, but do not seek for minute and technical knowledge, the case is different. What one of the general public, walking into a collection of birds, desires to see, is not all the birds that can be got together; he does not want to compare a hundred species of the sparrow-tribe side by side; but he wishes to know what a bird is, and what are the great modifications of bird-structure; and to be able to get at that knowledge easily. What will best serve his purpose is a comparatively small number of birds, carefully selected, and artistically as well as accurately set up, with their different ages, their nests, their young, their eggs, and their skeletons, side by side, and, in accordance with the admirable plan which is pursued in this museum, a tablet, telling the spectator, in legible characters, what they are and what they mean. For the instruction and recreation of the public, such a typical collection would be of far greater value than any many-acred imitation of Noah's ark.

Lastly comes the question as to when biological study may best be pursued. I do not see any valid reason why it should not be made, to a certain extent, a part of ordinary school-training. I have long advocated this view, and I am perfectly certain that it can be carried out with ease, and not only with ease, but with very considerable profit to those who are taught; but then such instruction must be adapted to the minds and needs of the scholars. They used to have a very odd way of teaching the classical languages when I was a boy. The first task set you was to learn the rules of the Latin grammar in the Latin language—that being the language you were going to learn. I thought then that this was an odd way of learning a language, but did not venture to rebel against the judgment of my superiors. Now, perhaps, I am not so modest as I was then, and I allow myself to think it was a very absurd fashion. But it would be no less absurd if we were to set about teaching biology by putting into the hands of boys a series of definitions of the classes and orders of the animal kingdom, and making them repeat them by heart.

That is a very favorite method of teaching, so that I sometimes fancy the spirit of the old classical system has entered into the new scientific system, in which case I would much rather that any pretense at scientific teaching were abolished altogether. What really has to be done is to get into the young mind some notion of what animal and vegetable life is. You have to consider in this matter practical convenience as well as other things. There are difficulties in the way of a lot of boys making messes with slugs and snails; it might not work in practice. But there is a very convenient and handy animal which everybody has at hand, and that is himself; and it is a very easy and simple matter to obtain common plants. Hence, the broader facts of anatomy and physiology can be taught to young people in a very real fashion by dealing with the broad facts of human structure, such as hearts, lungs, and livers. Such viscera as they cannot very well examine in themselves may be obtained from the nearest butcher's shop. In respect to teaching them something about the biology of plants, there is no practical difficulty, because almost any of the common plants will do, and plants do not make a mess—at least they do not make an unpleasant mess; so that, in my judgment, the best form of biology for teaching to very young people is elementary human physiology on the one hand, and the elements of botany on the other; beyond that I do not think it will be feasible to advance for some time to come. But then I see no reason why in secondary schools, and in the science classes, which are under the control of the Science and Art Department—and which, I may say, in passing, have, in my judgment, done so very much for the diffusion of a knowledge over the country—I think that, in those cases, we may go further, and we may hope to see instruction in the elements of biology carried out, not, perhaps, to the same extent, but still upon somewhat the same principle, as we do here. There is no difficulty, when you have to deal with students of the ages of fifteen or sixteen, in practising a little dissection and getting a notion, at any rate, of the four or five great modifications of the animal form, and the like is true in regard to plants.

While, lastly, to all those who are studying biological science with a view to their own edification, or with the intention of becoming zoölogists or botanists; to all those who intend to pursue physiology—and especially to those who propose to employ the working years of their lives in the practice of medicine—I say that there is no training so fitted, or which may be of such important service to them, as the thorough discipline in practical biological work which I have sketched out as being pursued in the laboratory hard by.

I may add that, beyond all these different classes of persons who may profit by the study of biology, there is yet one other. I remember, a number of years ago, that a gentleman who was a vehement opponent of Mr. Darwin's views, and had written some terrible articles against them, applied to me to know what was the best way in which

he could acquaint himself with the strongest arguments in favor of evolution. I wrote back in all good faith and simplicity, recommending him to go through a course of comparative anatomy and physiology, and then to study development. I am sorry to say he was very much displeased, as people often are with good advice. Notwithstanding this discouraging result, I venture, as a parting word, to repeat the suggestion, and to say to all the more or less acute lay and clerical "paper-philosophers"[1] who venture into the regions of biological controversy—Get a little sound, thorough, practical, elementary instruction in biology.

HOW THE EARTH WAS REGARDED IN OLD TIMES.[2]

FROM THE FRENCH OF FLAMMARION.

WE are too apt in these times of popular education, and the cheap diffusion of knowledge, to forget the cost of scientific truth. We formulate a fact or principle, and administer it in the school-room, with but little regard to the circumstance that it may have cost thousands of years of toil to discover and establish it. We have found out, for example, a great deal about the figure, motions, and astronomical relations of the earth, with such exactness that, as Prof. Young tells us, we know the semi-diameter of our globe at the equator within two hundred feet—while to go "around the world" is now a mere frolic; and all this knowledge is given to children in an hour's lesson. But how few appreciate the long struggle of the human intellect in arriving at these simple results! Let us hastily glance at the early efforts of the human mind in trying to find out what sort of thing this earth is, in its form, extent, and relation to the heavenly bodies that surround it.

The history of the growth of any branch of knowledge has a double interest: that which comes from the knowledge itself, and its relation to the history of the operations of the human mind. Men think under the limitations of their times both as regards the extent

[1] Writers of this stamp are fond of talking about the Baconian method. I beg them, therefore, to lay to heart these two weighty sayings of the herald of Modern Science:

"Syllogismus ex propositionibus constat, propositiones ex verbis, verba notionum tesseræ sunt. Itaque si notiones ipsæ (*id quod basis rei est*) confusæ sint et temere a rebus abstractæ, nihil in iis quæ superstruuntur est firmitudinis."—("Novum Organon," ii., 14.)

"Huic autem vanitati nonnulli ex modernis summa levitate ita indulserunt, ut in primo capitulo Geneseos et in libro Job et aliis scripturis sacris, philosophiam naturalem fundare conati sint; *inter vivos quærentes mortua*."—(*Ibid.*, 65.)

[2] The cuts of this article are from Flammarion's "History of the Heavens," and we have made free use of the text of Blake's "Astronomical Myths," which is based on Flammarion's work.

of knowledge and the intellectual processes to which they are habituated. They reason as they can on such materials as they have. If they have not learned to observe, they come to conclusions without observations. If they do not know that there are such things as laws of Nature, their inquiries are not directed to find them. If they

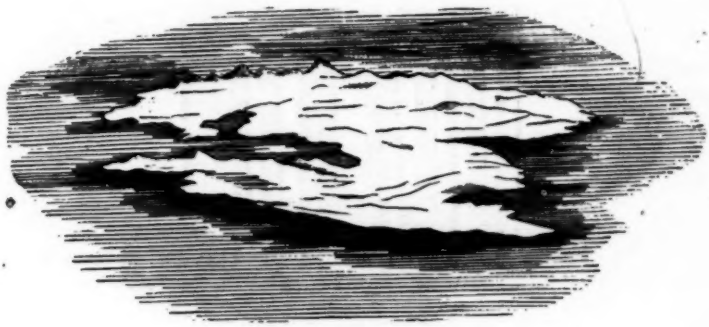

FIG. 1.—THE EARTH FLOATING.

think that the mind is the measure of Nature, they will search in their own reflections for the explanations of Nature; and when they have got out plausible results, or which agree with logic, they will impose their conclusions upon Nature as if they represented the truth. The human mind is essentially active and will make theories; and the

FIG. 2.—THE EARTH WITH ROOTS.

less its knowledge the feebler are the restraints of reason and the bolder the spirit of speculation. We must therefore expect that, in regard to the knowledge of the earth when nothing was actually known about it in early times, there must have been an enormous amount of crude conjecture, futile reasoning, and absurd fancy, or rather much that so appears to us now, although it may have been put forth at first as sober and honest belief.

Aristotle, who lived in the fourth century B. C., and studied Na-

ture with great earnestness and assiduity, held many views concerning the earth that were very reasonable for his time. Yet, in the absence of facts, nothing was left for him but to rely upon logic. He had certain ideas of what is *natural* and what is *perfect*, and from

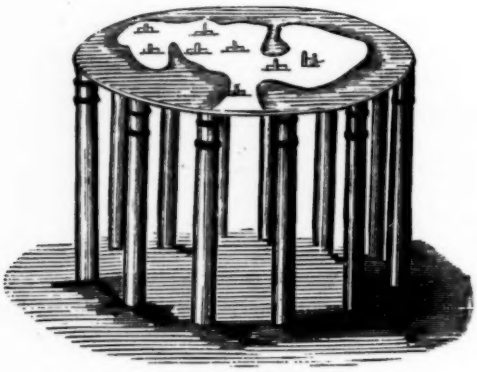

FIG. 3.—THE EARTH OF THE VEDA PRIESTS.

these he reasoned as to what *must be* and therefore what is. To the question whether the earth turns or the heavens turn, he replies that the earth is *evidently* in repose, not only because we see it to be so, but because it is a necessity that it should be, that is, because repose is *natural* to the earth. If it be asked why the stars must move around

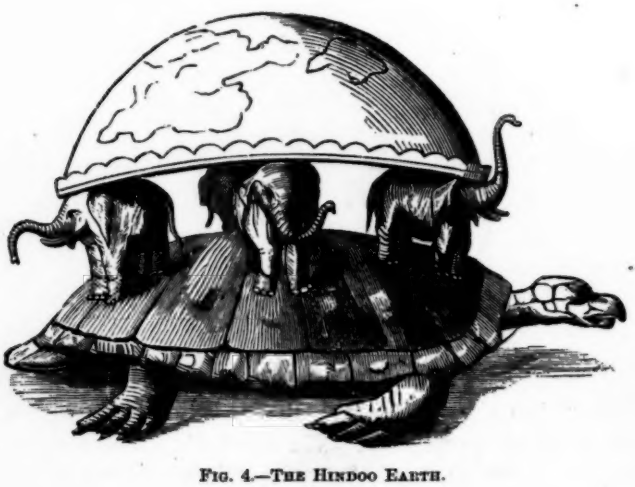

FIG. 4.—THE HINDOO EARTH.

the earth, he replies, it is natural that they should, because a circle is the most *perfect* line, because it has no ends, and it must therefore be described by the perfect stars. That the earth is the centre of the universe, and is at rest, is furthermore proved by Aristotle from theo-

logical considerations: thus, everything which performs any act has been made for the purpose of that act. Now, the work of God is immortality, from which it follows that all that is divine must have an eternal motion. The heavens have a divine quality, and for this reason they have a spherical shape and move eternally in a circle. Now,

FIG. 5.—ANAXIMANDER'S CYLINDRICAL EARTH.

when a body has a circular motion, one part of it must remain at rest in the centre; the earth is in the centre, and therefore motionless.

Aristotle, however, entertained many sensible views regarding the earth which were of course greatly "in advance of his times," and, among others, that the earth was spherical, for which he offered rea-

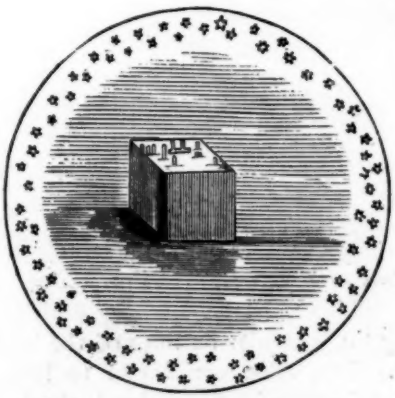

FIG. 6.—PLATO'S CUBICAL EARTH.

sons that are valid now. But how it could remain suspended in one place without any foundation to rest upon, puzzled him.

Among the various causes which in the absence of facts determined men's geographical opinions, one was the patriotic sentiment by which ignorant people were led to magnify their native country. According to the prepossessions of race, each one thought his own country to be located at the centre of the earth. Thus the Hindoos, who lived near the equator, and the Scandinavians, who lived nearer the pole, apply each a term to their own country which means

"the central habitation." The Greeks made Olympus the centre; the Egyptians, Thebes; the Assyrians, Babylon; the Hebrews, Jerusalem; while the Chinese always called their country the central empire. This is natural enough (as Aristotle would say), because most people regard their neighborhood as the centre of the universe, and the number of central railroads shows the continued force of this geometric idea.

One of the most primitive ideas concerning the earth represented it as a vast plain or flat island, surrounded on all sides by an inaccessible and interminable ocean. At the extremities and around the borders were placed the "fortunate isles," or imaginary regions, peopled by giants, pygmies, and extraordinary beings. The circumscribing

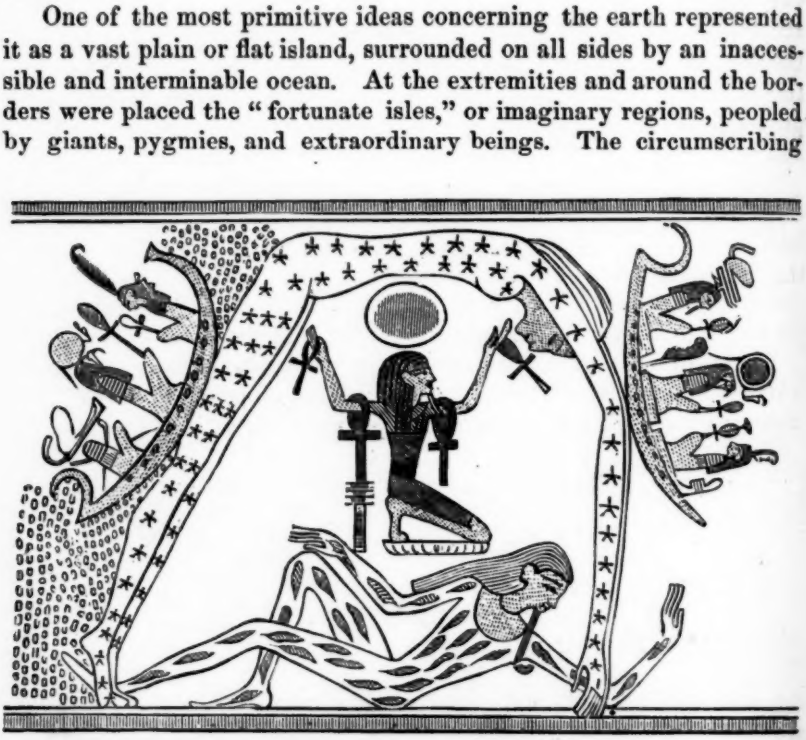

FIG. 7.—EGYPTIAN REPRESENTATION OF THE HEAVENS AND EARTH.

water surrounding the irregular outlines of the land led to the idea of a universal ocean. But, when men began to have experience of the sea by early navigation, the idea of a circular horizon always observed led to the notion that the ocean was bounded, and the whole earth came to be represented as contained in a circle, beneath which were roots reaching downward without end.

The priests of Veda, the scriptures of Buddhism, asserted that the earth was supported on twelve columns, which they very ingeniously turned to their own account by asserting that these columns were sustained by virtue of the sacrifices that were made to the gods, so that if these were not made the earth would collapse.

"These pillars were invented in order to account for the passing of the sun beneath the earth after his setting, for which at first they

were obliged to imagine a system of tunnels that gradually became enlarged to the intervals between the pillars."

The Hindoos held the earth to be hemispherical, and to be supported like a boat turned upside down upon the heads of four elephants, which stood on the back of an immense tortoise. It is usually said that the tortoise rested on nothing, but the Hindoos maintained that it floated on the surface of the universal ocean. The learned Hindoos, however, say that these animals were merely symbolical, the four elephants meaning the four directions of the compass, and the tortoise meaning eternity. The idea that the earth floated long prevailed, and was adopted by Thales, the early Greek philosopher, and by Seneca several centuries later.

Anaximander, a philosopher of the sixth century before Christ, represented the earth as a cylinder, the upper face alone of which is inhabited. He computed its proportions, and stated that it is one-third as high as its diameter; and he declared that it floats freely in

FIG. 8.—THE EARTH OF THE LATER GREEKS.

the centre of the celestial vault, because there is no reason why it should move to one side rather than to the other. Leucippus, Democritus, Heraclitus, and Anaxagoras, all agreed with him, and Anaximenes added the opinion, in consequence of the importance of air in the world, that the earth is supported on compressed air.

Plato was a mathematician, and excogitated the universe out of the depths of his geometrical consciousness. In explaining how things came about, he said that matter in itself had no form or properties, but God in the beginning invested it with a sort of triangular constitution. Afterward, taking a certain number of these primitive triangles, he composed the four primary elements. Fire, the most subtile, is made up of the smallest number of triangles, and has the figure of a pyramid. Water-particles are solids of twenty faces, while the earth-element is cubical or bounded by right-angled triangles. The cube with its six equal faces appeared to Plato to be the most *perfect* of solids, and therefore most suitable for the earth, which was to stand in the centre of the universe.

How the earth is supported was ever a perplexing question among ignorant nations. Thus, in the opinion of the old Greenlanders, as handed down from antiquity, the earth is upheld by pillars, which are so consumed by time that they often crack, and, were it not that they are sustained by the incantations of the magicians, the earth would long since have broken down.

It is hardly possible for us now to enter into that gross anthropomorphic state of mind by which, in primitive times, the phenomena of the universe were all represented in terms of human personality; nor can we even say how literally such views were held. But cer-

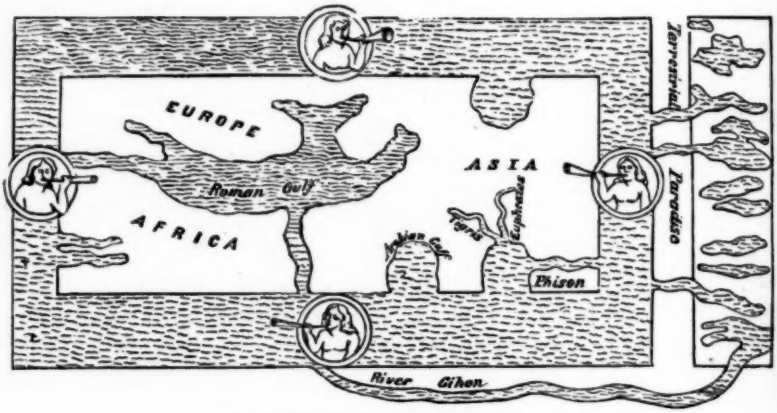

FIG. 9.—THE COSMOGRAPHY OF COSMAS.

tainly some of the representations are funny and fantastic. Thus, "an ancient Egyptian papyrus in the Library of Paris gives a very curious hieroglyphical representation of the universe. The earth is here imaged under the form of a reclining figure, and is covered with leaves. The heavens are personified by a goddess, who forms the vault by her star-bespangled body, which is elongated in a very peculiar manner. Two boats, carrying one the rising sun and the other the setting sun, are represented as moving along the heavens over the body of the goddess. In the centre of the picture is the god Maon, a divine intelligence, which presides over the equilibrium of the universe."

Strabo, one of the greatest geographers of antiquity—born A. D. 19—held to the sphericity of the earth, but of course regarded it as the motionless centre of the universe. He considered the moon and stars as only meteors, nourished by the exhalations of the ocean, and firmly maintained that no part of the earth can be inhabited save that which was known to the ancients. The form of the habitable world he held to be like that of a cloak, measuring in length from east to west 70,000 stadia (about 8,000 miles), while its breadth is less than 30,000 stadia (3,600 miles). It is bounded by regions unin-

habitable, on the one side from excessive heat and on the other from excessive cold. "The habitable world was thus much longer from east to west than it was broad from north to south: whence come our terms *longitude*, whose degrees are counted in the former direction, and *latitude*, reckoned in the latter direction."

In the fifth, sixth, and seventh centuries of the Christian era science made little progress in any direction, and, in regard to the ideas of the earth, the fathers of the Church contented themselves with pouring out their invective upon the idea that it is a globe, employing Scriptural reasons, which continued to be used even in the fifteenth century by the monks of Salamanca. In the year A. D. 535, Cosmas, surnamed *Indicopleustes*, after his voyage to India, wrote a work entitled "Christian Topography," in which he propounded the system of a square earth, with solid walls for supporting the heavens. He undertook to bring the opinions of the fathers into a methodical

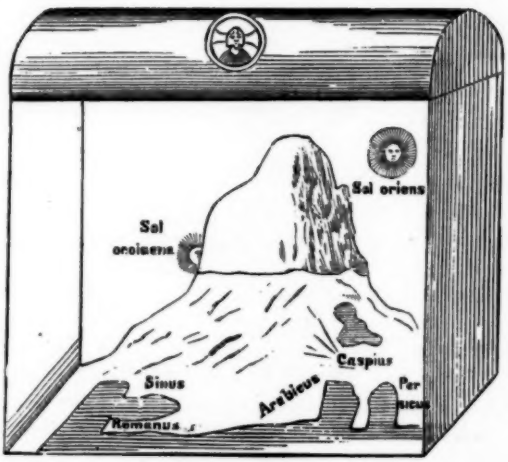

FIG. 10.—THE EARTH AND FIRMAMENT.

shape, and to explain the heavens and the earth in accordance with Scripture. We quote M. Flammarion's description of his system:

"According to Cosmas and his map of the world, the habitable earth is a plane surface. But, instead of being supposed, as in the time of Thales, to be a disk, he represented it in the form of a parallelogram, whose long sides are twice the shorter ones, so that man is on the earth like a bird in a cage. This parallelogram is surrounded by the ocean, which breaks in in four great gulfs, namely, the Mediterranean and Caspian Seas, and the Persian and Arabian Gulfs.

"Beyond the ocean in every direction there exists another continent, which cannot be reached by man, but of which one part was once inhabited by him before the deluge. To the last, just as in other maps of the world and in later systems, he placed the *Terrestrial Paradise* and the four rivers that watered Eden, which come by subterranean channels to water the post-diluvian earth.

"After the fall, Adam was driven from paradise, but he and his descendants remained on the coasts until the deluge carried the ark of Noah to our present earth.

"On the four outsides of the earth rise four perpendicular walls which surround it and join together at the top in a vault, the heavens forming the cupola of this singular edifice.

"The world according to Cosmas was, therefore, a large oblong box, and it was divided into two parts. The first, the abode of men, reaches from the earth

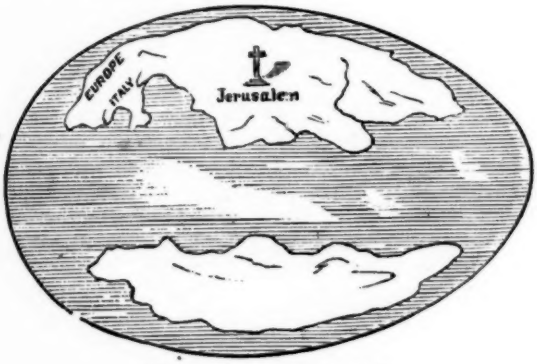

FIG. 11.—THE EARTH AS AN EGG.

to the firmament, above which the stars accomplish their revolutions; there dwell the angels, who cannot go any higher. The second reaches upward from the firmament to the upper vault, which crowns and terminates the world. On this firmament rest the waters of the heavens.

"Cosmas justifies this system by declaring that, according to the doctrine of the fathers and the commentators on the Bible, the earth has the form of the tabernacle that Moses erected in the desert; which was like an oblong box, twice as long as broad. But we may find other similarities—for this land beyond the ocean recalls the Atlantic of the ancients, and the Mohammedans, and Orientals in general, say that the earth is surrounded by a high mountain, which is a similar idea to the walls of Cosmas.

"God, he says, in creating the earth, rested it on nothing. The earth is, therefore, sustained by the power of God, creator of all things, supporting all things by the word of his power. If below the earth or outside of it anything existed, it would fall of its own accord. So God made the earth the base of the universe, and ordained that it should sustain itself by its own proper gravity."

Cosmas says that the earth, a sort of great square box circumscribed on all sides by high walls, is divided into three parts: first, the habitable earth, which occupies the middle; secondly, the ocean, which surrounds this on all sides; and, thirdly, another dry land, which surrounds the ocean, terminated itself by these high walls, on which the firmament rests. The habitable earth is always higher as we go north, and the southern countries much lower, so that the Tigris and the Euphrates, which run south, are more rapid than the Nile, which runs northward. The sun, moon, planets, and comets, all set behind

a large conical mountain; and accordingly as the sun disappears and emerges at points higher or lower is the varying length of day and night. On his view the stars were impelled by angels, who either carried them on their shoulders, rolled them in front of them, or drew them behind, it being remarked that "each angel that pushes a star takes great care to observe what the others are doing, so that the relative distances between the stars may always remain what they ought to be."

The learned Bede, known as the Venerable, who lived in the eighth century, regarded the earth as formed upon the model of an egg. He says:

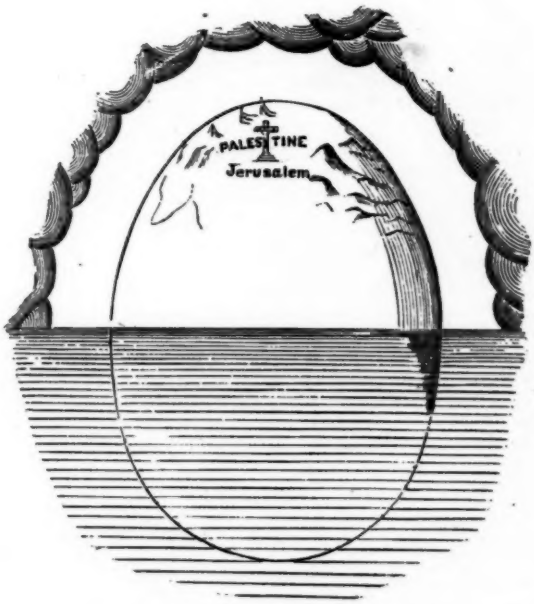

FIG. 12.—THE EARTH AS A FLOATING EGG.

"The earth is an element placed in the middle of the world, as the yolk is in the middle of an egg; around it is the water, like the white surrounding the yolk; outside that is the air, like the membrane of the egg; and round all is the fire, which closes it in as the shell does. The earth, being thus in the centre, receives every weight upon itself; and, though by its nature it is cold and dry in its different parts, it acquires, accidentally, different qualities; for the portion which is exposed to the torrid action of the air is burned by the sun, and is uninhabitable; its two extremities are too cold to be inhabited; but the portion that lies in the temperate region of the atmosphere is habitable. The ocean, which surrounds it by its waves as far as the horizon, divides it into two parts, the upper of which is inhabited by us, while the lower is inhabited by our antipodes; although not one of them can come to us, nor one of us to them."

It is said that a great number of the maps of the world, at the period of Bede, followed this idea, although the necessity was per-

ceived that the great earth-egg should not be left without some kind of support. To meet this requirement Edrisi, an Arabian geographer of the eleventh century, broached the idea that the earth is like an egg, with one-half plunged in water. According to him, the known world forms only a single half of the egg, which floats in the great ocean like an egg in a basin. This notion got currency with artists and map-makers, and continued, it is said, as a mode of representing the earth for many centuries.

FIG. 13.—EIGHTH-CENTURY MAP OF THE WORLD.

"In a manuscript commentary on the Apocalypse, which is in the library of Turin, is a very curious chart, referred to the tenth, but belonging possibly to the eighth century. It represents the earth as a circular planisphere. The four sides of the earth are each accompanied by a figure of a wind, as a horse on a bellows, from which air is poured out, as well as from a shell in his mouth. Above, or to the east, are Adam and Eve, with the serpent. To their right is Asia, with two very elevated mountains—Cappadocia and Caucasus. Thence comes the river Eusis, and the sea into which it falls forms an arm of the ocean which surrounds the earth. This arm joins the Mediterranean, and separates Europe from Asia. Toward the middle is Jerusalem, with two curious arms of the sea running past it; while to the south there is a long and straight sea in an east and west direction. The various islands of the Mediterranean are put in a square patch, and Rome, France, and Germany, are indicated, while Thula, Britannia, and Scotia, are marked as islands in the northwest of the ocean that surrounds the whole world."

And so the history goes on, geographical facts being mingled with fable, superstition, ancient mythology, and modern theology, until the era of maritime discovery, inaugurated by adventurers like Columbus, who discovered a new continent, and Magalhaens, who first circumnavigated the globe. From that period the advance of geographical knowledge has been in a great measure freed from the embarrassments of superstition, and has been steady and rapid in all the various fields of exploration.

HOW THE EARTH WAS EXPLORED IN 1876.[1]

FROM JUDGE DALY'S ADDRESS.

FROM the mode of regarding the earth entertained in old times, let us now pass to the modern method, and what has been accomplished by geographical investigation in a single year. No better illustration can be found of the great change which science has wrought in the mental habits of man than the contrast between the empty speculations of the olden time, and the immense and positive results of observation and exploration by which our geographical knowledge has been augmented, in even a single year. Judge Daly's annual *résumé* of the previous year's work in geographical inquiry, given before the society of which he is president, is so careful, so trustworthy, and so complete, that it is looked for with eagerness by many readers. By his kind permission, we avail ourselves of the discourse, condensing some parts and quoting others. Those who do not like this mangling of an author's work had better get the discourse in its full text, which will be issued in pamphlet form.

We are informed that the past year has been marked, not only by investigations and discourses, but by the establishment of several new geographical societies, and a large increase in the membership of the old. Having their origin in the "Society of the Argonauts" founded in Venice in 1688, there are now thirty-eight such societies in existence. Physical geography, to which I shall first refer, is a line of inquiry in which there has been great activity during the past year, as shown by the number of works that have been published, and the papers that have been read upon the various branches of this great subject.

"At a meeting of the British Association at Glasgow, last September, Sir William Thomson considered the subject of the interior of the earth. He said that the greatest depth that had been reached in observations of underground temperature was scarcely one kilometre

[1] Condensed from the annual address of Chief-Justice Charles P. Daly, President of the American Geographical Society, delivered January, 1877.

(which is less than a mile); that, whatever might be the age of the earth, we might be sure that it was solid in the interior—not through its whole volume, as there were spaces in volcanic regions occupied by liquid lava, but that this portion was small in comparison to the whole—and that any geological hypothesis must be rejected which assumes that the earth is a shell resting on a liquid mass. He also considered the question, first, of the accuracy of the earth as a timekeeper; and, second, the permanence of its axes of rotation. Since the first known observation of an eclipse of the moon at Babylon, on the 19th of March, 721 B. C., the earth has lost a portion of its velocity, and is now, as a timekeeper, going slower; and his observation upon the question of the earth's axis was, in effect, that if causes existed adequate to produce a change in the position of the axis by the upheaving of the surface, or otherwise, the result, even if sudden, would not be very great, or produce any extraordinary effect. Many important observations were made, at the same meeting, upon the tides, ocean temperature, and currents, and upon the physical geography of the sea, founded upon the results of the voyage of the Challenger."

Of this expedition Sir Wyville Thomson has given the general results. The superficial area of the world is 197,000,000 square miles, of which 140,000,000 are covered by the sea at an average depth of 15,000 feet. The floor of this region is, to a certain degree, comparable to the land. It has its hills, valleys, and great plains; its various soils; its climates, and its special races of inhabitants, depending on the conditions of climate and soil for their distribution.

"The vessel departed from England in December, 1872. She crossed the Atlantic four times in 1873, in a course of nearly 20,000 miles. In 1874 she went southward from the Cape of Good Hope, dipping within the antarctic circle as far as she could, and then traversed the Australian and New Zealand seas and the interior of the Malay Archipelago, arriving at Hong-Kong on November 10, 1874, after a run in that year of 17,000 miles. In 1875 she traversed the Pacific, in a course of about 20,000 miles, and then crossed the Atlantic for the fifth time, reaching England May 24, 1876. The three general results are—1. The knowledge obtained of the contour of the bottom, and the nature of the deposits now being formed. 2. The distribution of deep-sea climate. 3. The nature and distribution of the peculiar race of animals now found at the bottom of the sea. In the Pacific there is an enormous extension of water of great depth—in many cases beyond 18,000 feet. In the North Atlantic the greater portion has a depth of 12,000 feet; and in the South Atlantic, on each side of what is known as the Dolphin rise, there are troughs usually 18,000 feet deep, which form marked depressions roughly parallel with the arc of the South American and African Continents. The whole bottom of the sea is gradually receiving accumulations, giving rise to formations which must be regarded as the rocks of the future. The *débris* of

the land was found to be carried out into the sea some hundreds of miles, and clays were being formed, mixed up with the *débris* of animals. Within a certain distance of the land the deposits, to a great extent, were formed of this material. Over a great part of the North Atlantic there is being deposited the *Globigerina ooze*—composed, principally, of small chambered shells, extremely minute; and these shells were found in enormous quantities. This deposit is almost entirely of carbonate of lime, and the only rock it could form would be limestone; therefore, over a large part of the North Atlantic, and over many other parts of the world, this limestone is being laid down." These creatures live at and near the surface, and thence the whole of this sort of material at the bottom is derived. "It might be supposed that this formation ought to be as universal as is the distribution of these animals on the surface. Singularly enough, this is not the case. At the depth of 12,000 feet the shells become rotten and yellow; at 13,000 feet there are no shells, and the bottom is one of homogeneous red mud, which, instead of consisting of carbonate of lime, is ordinary clay. I may here interpolate a fact to show how abundant animal life is at or very near the surface of the ocean. The steamer Great Eastern was lately in dock at Milford Haven for the examination of her bottom, which had not been scraped since 1867. Her bottom was found covered with an enormous multitude of mussels, clustered together in one dense and continuous deposit, extending over 52,000 square feet, and which, upon a calculation made, amounted to not less than *three hundred tons*' weight, or enough to load with a full cargo two ordinary collier brigs.

"Another curious fact observed in the voyage of the Challenger was, that all over the bottom of the sea there is a large quantity of pumice, showing that there are volcanoes, either below the water or otherwise, that are constantly throwing out material. This pumice, which is the froth of lava, is frequently so light as to float on the water, and wherever they were, in any part of the world, they saw it moved about by the current over the surface of the sea. They found living in the sea, on the surface, or just below, a great quantity of beautiful organisms called *Radiolarians*. They increase with the depth, and many occur at great depths that are not found on the surface at all. The impression formed was that they lived all through the sea, and down to the greatest depths.

"The whole bottom of the Pacific, or the greater part of it, is red clay. The temperature of the ocean at 13,000 feet is very low. It is usually but a little above the freezing-point at the bottom of the Pacific and the Atlantic, and portions of the Southern Sea. The general temperature gradually falls from the surface until the depth of 13,000 feet, below which there is, throughout the sea, a uniform temperature of 37° or 34°, or a little below the freezing-point. The question arose, Whence does the ocean derive this low and uniform temperature? It

is a question of great difficulty; and the conjecture made is, that it is an inflow of the cold water from the vast area of the antarctic."

The geographical work of the United States has been more limited than usual, owing to delay and smallness of appropriations. The Coast Survey continues its work: in the Gulf of Mexico careful soundings have been made, and observations on the temperature of the water and the flow of currents, which will throw light on the Gulf Stream. Triangulations were pushed eastward from the Pacific Coast Range to the Sierra Nevada, some of the triangles observed having sides over 150 miles long; a series of telegraphic determinations of longitude have been made for the purpose of correcting our charts of the West India Islands, one point at least having been located on each island. Triangulation along Lakes Ontario, Erie, and Michigan, has been continued, the topography of Niagara River completed, many points determined for the State survey of Michigan, and the elevation of the Great Lakes newly determined. Lake Ontario is found to be 247.25 feet and Lake Erie 573.58 feet above mean tide at New York. Reports of geographical and topographical work in Montana, the Yellowstone Park, Southern Colorado, Northern New Mexico, and Arizona, have been issued. The geographical surveys west of the 100th meridian, under Lieutenant Wheeler, have been continued. About 25,000 square miles were traversed by the various parties. Some interesting Spanish mines were found in New Mexico. A survey was carried on in the neighborhood of Lake Tahoe, in California. The depth of the lake was found to exceed 2,200 feet. The examination of the Colorado River, with reference to determining the practicability of diverting it from its channel to irrigate the deserts of Southeastern California, has been completed. The lowest part of the desert is 200 feet below the sea, and it was found that an area of 1,600 square miles could be flooded; but constantly-shifting sands would make it a continual expense, and the evaporation from the surface of such a lake would exceed the water flowing in the Colorado in a dry season. Thirteen atlas sheets of Lieutenant Wheeler's survey have been issued; they are upon a scale of eight miles to the inch, and cover a large part of Nevada, Utah, Arizona, New Mexico, and Colorado. The survey of the Territories under Profs. Hayden and Powell was carried on, and much has been learned of the region embracing Colorado, Utah, and Southeastern Nevada. A triangulation party climbed and measured Blanco Peak, near Fort Garland, in Colorado, which, if not the highest, is next to the highest peak in the Rocky Mountains. It is 14,464 feet high. Over fifty of the most elevated peaks in that range are in the State of Colorado, running from 14,000 to 14,500 feet, so close that the utmost care has been required to determine which is the highest.

Eastern Utah was surveyed from the Colorado River to and over the Wahsatch Mountains between parallels 38° and 39° 15′. The region

is characterized by great plateaus bounded by lines of cliffs from 1,000 to 2,000 feet in height, varying from 20 to 200 miles in length, the whole intersected with a network of deep and narrow cañons, presenting nearly impassable barriers. Of one section of about 7,000 square miles, only about one per cent. is available for agriculture; about five per cent. is covered by pine and spruce, the remainder being a desert waste. There are large quantities of excellent coal, but no precious metals were discovered. The average elevation of this region is about 7,000 feet. Another section in Southwestern Utah and Southeastern Nevada of about 4,000 square miles was found one of the most barren regions of the whole Great Basin. It is marked by ranges rising to 9,000 feet, with broad desert valleys between. Little timber-land or land fit for cultivation was found, the pasturage being of the poorest quality. The climate is milder than that of Eastern Utah, and very dry, the annual rainfall not exceeding four inches. "There is no coal in this region, but it is known to contain large amounts of silver. The well-developed mining district of Pioche was within the region examined, and also a newly-organized district at Leeds, on the Virgin River, Utah, where silver, instead of occurring in veins, is disseminated in the form of horn-silver, through a stratum of sandstone belonging to the Jura Trias. Between 4,000 and 5,000 men have gathered at this last-named district (Leeds) within the past few months."

Extensive collections have been made illustrative of the arts and industries of the Indian tribes, embracing totemic carvings, stone implements, clothing, ornaments, furniture, and manufactures, of the Pueblo race; heraldic columns from Vancouver's Island, of painted wood from 25 to 40 feet high, erected in front of their dwellings, which are communal, holding from 100 to 300 people. These houses are made from slabs rived out of great tree-trunks with wooden wedges and stone mallets. Canoes were obtained 60 feet in length, dug from single logs; many tons of ancient stone implements, said to surpass in beauty of finish any aboriginal remains of like nature hitherto discovered, together with pottery, have been forwarded to the Smithsonian Institution from Southern California. The United States Signal Service Corps "is making rapid advances toward a complete knowledge of the conditions and causes of the American climate. They have nearly completed the most extensive collection of altitudes of places in North America which has ever been gathered. The list includes several thousand profiles, representing almost every railroad and canal. From this and other data they are making a relief model of North America on a large scale. A telegraph-line has been built by them from Central Texas across the Llano Estacado, that dreaded waterless desert, and one across the high and arid plateaus and ranges of Southern New Mexico and Arizona to San Diego, on the Pacific. This gives an unbroken line from Savannah along the southern border of the United States, stretching from ocean to ocean. Thirty

meteorological stations are placed along the line, the highest being 6,800 feet above the sea. Another line of stations follows the Rio Grande River from its mouth to the elevated plateau of Colorado.

"The Mexican telegraph-lines now extend from the mouth of the Rio Grande River to San Luis, thence to Tampico, and thence through Vera Cruz along the coast nearly to the extremity of Yucatan. The Signal Service are preparing to place stations down even to Yucatan. The Gulf of Mexico has been nearly encircled with a telegraph-line, along which meteorological stations will be placed at such short intervals that no hurricane or storm can move from the Gulf without notice of its escape and the direction of its flight being given at once to the whole country.

"Arrangements have been made for a chain of stations to the extreme eastern end of the West Indies, all connected by telegraph with the Washington office. If Congress is wise enough to give sufficient appropriation to carry out these excellent plans, it will be impossible for any hurricane to enter the United States from the south unheralded, for hourly bulletins of its progress can be posted in every seaport. Who can estimate the lives and treasure that such an arrangement may save? Congress cannot be too generous to the Signal Service.

"To show the power of the telegraph in this connection, I may mention that General Myer recently sent, at twelve o'clock at night, an order to each meteorological station in this country. It was unexpected by the corps, but so perfect is the discipline that within ninety minutes the Washington office received answers from every station, even including that on the lofty elevation of Pike's Peak, and the lonely desert of Fort Yuma.

"At General Myer's suggestion, an international meteorological organization was effected in 1873. Observations are now taken once a day, *simultaneously*, at every meteorological station in the world, and the results forwarded to the Signal Service Office at Washington.

"Every day this office publishes a bulletin, giving the record of these simultaneous observations from all stations. The date of the bulletin is necessarily long enough after the observations to admit of their reaching Washington. The climate of the world is thus placed under our eyes at once. When this is carried to perfection, the laws that govern climate may be determined."

The petrified forest in the desert of Humboldt County, Northwestern Nevada, has been examined. The stumps of the trees now transformed into rock are found in an upright position, with their roots imbedded in the soil as when growing—many of the stumps measuring from fifteen to twenty feet in circumference; and the ground was found strewed with trunks and limbs in the same petrified state, retaining their natural shape and size. There were no liv-

ing trees, nor any trace of vegetation, in the vicinity, except a growth of stunted sage-brush.

"The largest tree yet found in California was discovered during the year in King's River Valley, Fresno County. Measured from the highest point to which a man could reach, it was found to be 150 feet in circumference, within a few inches, and its height was estimated at 160 feet. It is probably the largest tree in the world."

A report of the international commission for the survey of the boundary-line between the United States and British North America, from the Lake of the Woods to the Rocky Mountains, has been published. The region was one hitherto unexplored by whites, and was found, as represented by the Indians, to consist mainly of swamps, making the survey a difficult one. To this were added the rigors of the climate, as the work had to be conducted chiefly in the winter, when the swamps were frozen and with the mercury at 45° below zero. The country west of the Red River would be a fine grazing-ground but for the myriad mosquitoes which drive domestic cattle almost wild and keep them from gaining flesh. In one direction the boundary-line, in the course of thirty-five miles, crossed sixty-five pieces of water, twenty-five of which were lakes, requiring a survey by triangulation. Beyond Turtle Mountain the survey was extended over the Great Plains, the Great Coteau of the Missouri, and the Salt Lakes, and the arid, desolate country known as Les Mauvaises Terres. Beginning in 1872, the survey was completed in 1874 to the base of the Rocky Mountains, where they rise from the plain in precipitous peaks 10,000 feet high. The whole boundary from the Lake of the Woods to this point is now marked by stone cairns or earthen mounds, and by iron pillars at intervals of a mile for 135 miles along the boundary of Manitoba in British America, which, it is said, "is destined to become the great granary of the Dominion." There are, however, the drawbacks of the want of markets, the ravages of grasshoppers, and the scarcity of fuel. The latter difficulty may be obviated by developing the great bituminous coal-fields of the Saskatchewan. Immigration in this direction is going on; 4,000 Mennonites from Odessa, in Russia, have settled there, and also a colony of 300 Icelanders on the western shore of Lake Winnipeg.

The arctic event of the year has been the return of the English expedition of the Alert and Discovery, under Sir George Nares, from an attempt to reach the pole by way of Smith's Sound. The vessels had great difficulty in forcing their way through Smith's Sound and Kennedy's and Robeson's Channels. They were twenty-five days making their way from Cape Sabine to Discovery Bay, a distance of only 250 miles, beset with all the perils of arctic navigation.

"Regarded from a geographical and scientific point of view, the expedition was a success. I said in my annual address, several years ago, that to reach the pole was not the main object in an arctic ex-

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"Regarded from a geographical and scientific point of view, the expedition was a success. I said in my annual address, several years ago, that to reach the pole was not the main object in an arctic ex-

pedition; that that was a mere geographical feat, to which necessarily great *éclat* would be attached; but that the real object of such an expedition was to explore the arctic region in every direction as far as possible, to obtain scientific information in a quarter of the globe where it was of the highest interest—not only as respects the past physical history of the earth, but to enable us to unravel phenomena and obtain a knowledge of physical laws affecting its present condition which are of high scientific value, or, to express it in a popular form, of the greatest practical importance. This object has been to a considerable degree advanced by the English expedition. The Alert not only attained the highest latitude—82° 24′—ever reached by a vessel, and the sledge-expeditions the farthest northern point attained by man—83° 20′ 26″ north latitude—but the expedition, in an unknown region, discovered and traced a line of coast extending over nearly fifty degrees of longitude, ascertained to a considerable extent the nature of the Polar Sea bordering this newly-discovered coast, and collected a large amount of scientific information in the examination of both land and sea. A line of coast was explored 230 miles west of the spot where the Alert wintered—90 miles of which trends northwesterly to Cape Columbia, the extreme northern cape, 83° 7′ north latitude, 70° 30′ west longitude; thence westward for 60 miles to 79° west longitude, and from there gradually south to 82° 16′ north latitude and 83° 33′ west longitude, with no indication of land extending from there either westward or northward. The northeast and northern coast of Greenland was traced from Polaris Bay to a point east of Mount May in 80° 40′ west longitude, the farthest northern land seen in the expedition being in 82° 54′ north latitude and 48° 33′ west longitude (Cape Britannia and Mount Albert), and the Greenland coast was found to run from Mount May, in a southeasterly direction, to below the eighty-second parallel of north latitude; Lady Franklin's Bay, and Petermann's Fiord and its vicinity, were explored, to which must be added magnetic and meteorological and other scientific observations, and the labors of the naturalist, carried on in the winter, with the thermometer ranging at one time at 73° below zero.

"Being farther north than any former expedition, they passed an unparalleled arctic winter of one hundred and forty-two days—nearly five months—without the light and heat of the sun, and in the severest cold yet known. In the sledge-expedition of Commander Markham, in the autumn of 1875, to Cape Joseph Henry, the fall of snow was so enormous that the men had to draw their sledges through it up to their knees, and frequently up to their waists, so that, out of a party of twenty-four, twelve were severely frost-bitten, and three suffered amputation.

"In an attempt to communicate by a sledge-party with the Discovery, that vessel having wintered below [illegible]obeson Channel, Christian

Peterson, the Danish interpreter from Upernavik, who had been Dr. Hayes's sledge-driver, became so exhausted that nothing would keep him warm. They were consequently compelled to go back with him; and the poor fellow died shortly after his return to the vessel.

"In an expedition in the following April across the Polar Sea, north in the direction of the pole, the men had not only to draw their sledges, but two heavy boats fifteen and twenty feet long, over rugged floes of ice, separated by ridges sometimes thirty feet high—to make their way over the *débris* of the pack-ice broken up by the previous summer, and refrozen during the winter into chaotic, rugged masses of angular blocks, of every possible shape. They had frequently to cut their way with picks through the hummocks; and such were the contortions and checks, that they had frequently to go five times over the same ground; so that in making a distance of 76 miles toward the pole they actually traveled over 276 miles. Each man had to drag 236 pounds, and to work from ten to twelve hours a day. They could pull but a few feet at a time, and make but from one mile and a quarter to two miles and three-quarters a day. They were absent on this sledge-expedition, engaged in this incessant labor, for two months and a half; and, to add to their trials, the scurvy broke out among them, so that, when relief reached them, out of the seventeen of the party only five were able to drag the sledges. The sledge-party along the north coast of Greenland were beset with like difficulties. Enormous blocks of polar ice had been pressed against the shore, making the traveling one of incessant labor, so that seven days were occupied in moving only twenty miles. The scurvy also broke out with them; and, when they came in, two only were able to draw the sledges. The western sledge-party found the same heavy ice extending along the whole coast. They were also attacked by the scurvy, Lieutenant Aldrich being the only one who escaped; and relief fortunately reached them the last day that most of them were able to travel. . . .

"The return of the expedition, and its results, have given rise to a great deal of discussion, both in this country and in England. Sir George Nares is of opinion, and Dr. Petermann in a recent letter concurs with him, that any further attempt to reach a higher latitude by the way of Smith's Sound is hopeless, and that any future effort must be by the route between Spitzbergen and Nova Zembla. I fully agree in the correctness of this judgment, so far as respects any attempt to get farther north by the way of Smith's Sound in a vessel. I have never found sufficient facts to lead me to believe that there is an open polar sea that can be reached by a vessel, nor any physical reasons why there should be a great space of open water at the pole, or in its vicinity. This belief is a very old one. The supposed sea is to be found represented upon a map published 268 years ago. There may be such a sea. The knowledge we possess will not warrant the assumption that it does not exist; but it will warrant this statement—

that the more we become acquainted with the area of the polar basin, and the nearer we get to the pole, the fewer indications there are of the existence of such a sea. I am not, therefore, very hopeful that any vessel will be able to get much farther north than vessels have already attained; but I do believe, notwithstanding the result of the English expedition, that the polar area can be traversed much farther north in that direction by sledging, and that it can be done by the way of Smith's Sound as effectually as between Spitzbergen and Nova Zembla. The plan which Dr. Hayes laid before this Society eight years ago, of establishing a station at Fort Foulke, where subsistence can be easily obtained, and with which communication can be regularly kept up by sea, as a base from which expeditions may be directed to the north as favorable opportunities offer, I have always thought the best plan of polar exploration, and for many reasons preferable to sending out large expeditions. It would not require a large force, would afford opportunity for the training and experience in the arctic regions, which is requisite, and could be kept up at a comparatively small expense. Captain H. W. Howgate, of the United States Signal Service, has recently called public attention to a plan substantially of this character, and a bill embodying his suggestion is now before Congress, to establish a temporary station for the purpose of exploration at some point north of 81° north latitude, on or near the shore of Lady Franklin's Bay; and Captain I. L. Norton, a shipmaster, who has had some experience in the Antarctic, is maturing a like plan, which, he advises me, he will lay before this Society."

The several surveys instituted by our Government across the American Isthmus to ascertain the most feasible route for the construction of an interoceanic ship-canal have been completed, the result showing that the Nicaragua route is the most practicable. It will take ten years, at least, to construct it, and the cost is estimated at about $10,000,000.

"A cavern has been found in Cuba containing Carib remains, indicating that the whole of that island was formerly inhabited by the Caribs.

"Prof. Weiner has been occupied during the year in ethnological researches in South America, and reports from Pacha Camac that he has discovered glaciers in the Andes and Chili, which had been questioned by Agassiz; and Prof. Hartt, chief of the Brazilian survey, is reported to have recently made important geological discoveries in Brazil. The Government of Brazil has undertaken the measurement of an arc on the parallel of 23° south latitude, extending over nine or ten degrees of longitude, connecting the capital of the country with the great meridian of Brazil.

"The Amazon is now navigated by steamers 3,000 miles from its mouth, and several of its tributary rivers have been opened up to steam-navigation. I would especially call attention to the great com-

mercial importance to the United States of direct and regular communication from this country by steam with the mouth of the Amazon, in view of the importance of the regions of the Upper Amazon and its tributaries, which are now made accessible by steamers."

In Europe initiatory steps have been taken for the measurement of an arc of the meridian parallel with Algeria. The surveys in Austria have been actively prosecuted; 2,066 square miles have been surveyed in Galicia and Hungary, and 200,000 altitudes determined. The whole of the Tyrol, the greater part of Transylvania, and parts of Lower Austria and Bukowina, have been mapped. Surveys in Turkey and Greece promise at an early day a good map of the Balkan Peninsula. Deep-sea soundings have been made between Norway, the Shetlands, the Faroes, Iceland, and East Greenland.

The Russians and others have been active during the year in Asia, in the regions around the White Sea, in the country of the Caspian, the Altai and trans-Altai Mountains, the northern part of Pamir, in the lower part of the river Obi, upon the Irkoort River, from Wjernga to Kashgar, in the valley of Fergani, of the Shueli, and in the western part of the Chinese province of Yunnan; also in East and Northwest Mongolia, between the Himalayas and the Tian-shan, China, and Turkistan, in Japan and Siam, and the river Mekong in Cochin-China. The Siberian coast has been surveyed between parallels 45° and 52° north latitude; the soil is good, vegetation luxurious; lead, copper, gold, silver, and coal, were found.

The German Arctic Society, in pursuance of a plan for polar research, "dispatched an expedition which last July reached Obdorsk, the most northern settlement on the river Obi, where they met the Russian expedition, organized for the survey of the rivers Bar and Chuca, that flow into the sea of Kara, and the course of the river Obi, to determine the possibility of connecting these rivers with a canal. Thence the party made their way to the Kara Sea, a very difficult route; and, upon their return last autumn, they passed through the Kara Sea and the strait without any impediment from the ice, and have transmitted a very interesting account of their journey in Siberia. Prof. Nordenskiöld has again passed safely into the Kara Sea and to the mouth of the Yenisei, and has already returned. He found the Kara Sea free from ice in September, and declares that the navigability of the Yenisei is now ascertained, and is confident that a trade-route may be established to that river through the Kara Sea."

In Thibet, in Japan, in Siam, and in Persia, extensive explorations have been made. The great survey of India is going on at the rate of 40,000 square miles per annum. The American Palestine Exploration Society has suspended work, in accordance with the advice of the advisory committee in Beyrout, partly because of the disturbed condition of Turkey, and the continued commercial depression at

home. The engineers have, however, made a rapid reconnoissance of nearly the whole territory east of the Jordan.

"I have frequently called your attention to the remarkable remains that are found in the country east of the Jordan—the Moab Bashan Gilead of the Bible—of which, until the recent explorations, nothing comparatively was known. Though this part of Syria may be reached in a few days from the northern part of the Dead Sea, or from the sea of Galilee, it was not visited by travelers, in consequence of the rugged nature of the country and the hostile tribes of Bedouins that inhabit it. It has now been ascertained to abound in architectural and archæological remains of the greatest interest. It is literally strewed with the remains of towns and of structures, many of them remarkable for their massiveness, which belong to a past civilization, of which we know nothing. You will remember that some years ago, from the indications which then existed, I expressed the opinion that this must have been, at an early period, one of the chief routes between Asia and Africa, and the ruins which have since been found in the explorations carried on by the American society, and their extent, confirm that impression.

"Dr. William Thompson, the veteran American missionary and explorer in Syria, in a recent letter says that, in making a tour through this region, nothing ever impressed him so much as the richness of this field in the remains of ancient civilization. He says that there are not only acres on acres of splendid ruins, but fortifications, temples, baths, and theatres, the best preserved in existence, and which have evidently stood undisturbed for ages. While on the west side of the Jordan, he remarks, cities have been robbed to build other cities—just as the ruins of Tyre are now contributing ship-loads of stone toward building the present city of Beyrout—the east side of the Jordan has remained unmolested for 1,500 years; and that there exists there an unequaled combination of art and Nature in an untouched condition of splendor and ruin."

The work of exploration and investigation in respect to the unknown parts of Africa has been vigorously followed up during the year. The Niger, Volta, Ogowe, and Congo Rivers have been explored more or less fully. The source of Guango River has been reached by penetrating the interior across the Talamunga Mountains, which are from 4,000 to 5,000 feet high.

"When our fellow, M. du Chaillu, several years ago laid before us the account of the pygmies he had found in Western Africa, near the equator, it was received in certain parts of Europe with incredulity; but these pygmies of the western coast have since been seen by others, and the existence of races of pygmies is now established by the facts gathered by Schweinfurth, Miani, and others in Africa, and by recent researches in India. Mr. Marcette says that these pygmies were well known to the ancient Egyptians, and that there is a bass-

relief, in the sepulchre of the Necropolis of Saggarale, of the fifth dynasty, upon which two pygmies are represented, having the features of Dr. Schweinfurth's Akka. He says the pygmies of antiquity were natives of Pun, which he indentifies with the modern Somali country. The Phœnicians came from Pun, and were not an Asiatic race, and near them dwelt a race of dwarfs called Bess, who still exist in the Somali country."

The district of Akem, in the north portion of Ashantee, has recently been visited. The country is fertile, heavily wooded, well watered, and highly auriferous. "The climate is humid throughout the year; the men are capable of undergoing great fatigue, but are incorrigibly idle, and the women do all the work. Among the men he found an extraordinary growth or enlargement of the cheek-bones under the eyes. It is in the form of horns on each side of the nose, and so long that in some instances the man had to squint violently to see at all. The growth begins in childhood. The skin is not broken, but stretches over the horns like a glove. This phenomenon he thought peculiar to the tribe in Akem, as he did not find it in any other. Photographs of these horned men, it is said, have recently been received in England."

The circumnavigation of the Mwutan Nizigi (Albert Nyanza) is the important event of the year in Africa, establishing the connection between this lake and the Nile. It appears that the White Nile is navigable the whole way from Dufli to the lake, a distance of 164 miles. About 100 miles from Dufli there is a large branch of the river, extending north-northeast in the direction of the Nyam-Nyams. The country east of the lake has also been explored, and a chain of military posts established from Gondokoro to both Mwutan Nizigi and the Ukerewe (Victoria Nyanza). The Somerset River was reached, and a station established at Masuidi, the capital of Unyora. The Somerset Nile, which connects the two lakes, is navigable from Mwutan Nizigi to Murchison's Falls; but from there to the Karuma Rapids it abounds in swift water, having a fall of 700 feet between Murchison's Falls and Foueira.

Mr. Stanley, after exploring Lake Ukerewe, crossed the country of Unyora to the Mwutan Nizigi, reaching that lake at a point where a deep gulf (Beatrice Gulf), formed by a promontory called Unsongora, runs out for thirty miles in a southwesterly direction. The position of his camp on the lake is 31° 24′ 30″ east longitude, and 25′ north latitude. The country of Unyora extends along the eastern shore; that on the south shore is called Ruanda. On the west, opposite Gulf Beatrice, is Ukonju, peopled by cannibals, and the farther western shore to the north is the country of Ulegga. The people of the south and southwestern shores were very hostile. Stanley followed up the course of the Kitangule River, the main feeder of Lake Ukerewe, and circumnavigated Lake Windermere of Speke; and afterward, on

the frontiers of Karewega, found Lake Akengara, noted in Speke's map. When last heard from, in July, he was on his way to Unamyembi, intending to explore Lake Tanganyika, and then strike northward to the Mwutan Nizigi. Commander Cameron's journey is claimed to have settled the line of the Central African lake-sources. The chief products of Central Africa are ivory and slaves. Westward from Katanga there are large copper-mines; coal, cinnabar, and tin, were found; sugar-cane, rice, wheat, cotton, and hemp, grow well; the vegetable and mineral products would make the people of Africa industrious and prosperous, were they not ruined by the slave-trade. The way to stop this traffic is to open up the rivers Congo and Zambesi, for there is a way across the continent by a system of water navigation second to none in the world. A missionary station has been established on Lake Nyassa, in memory of Livingstone, with a view to the suppression of slavery, and every friend of humanity will unite in wishing success to this philanthropic endeavor which Livingstone had so deeply at heart. A way has been found from Zanzibar to the interior highlands which is free from the fever-swamps of the old route, and also from that great scourge of East Africa, the tsetse-fly, a fact of great importance in opening up Central Africa.

An Italian expedition started last February, for the exploration of the country on the east coast between Shoa and Lake Ukerewe. After many hardships, Liece, the capital of Shoa, has been reached, which will be made the base of a scientific exploration of the lakes. The expedition is to be absent four years.

"I regret exceedingly to hear of the recent death of Mr. Rebman, the well-known missionary, who first suggested the existence of a system of lakes in Central Africa, which was verified by the discoveries of Burton, Speke, Grant, Baker, Livingstone, Long, and Stanley."

There is little to record in regard to South Africa. The diamond-fields of the Orange Free State and the gold-fields of the Transvaal Republic have not only attracted the enterprising and industrious, but have also excited the cupidity of their English colonial neighbors, in a way which it is feared will prove anything but beneficial to the rising African republics.

During the last five years the great island of New Guinea, which thirty years ago was put down as an unknown land, has been the scene of active explorations. The country has been penetrated by way of Baxter and Fly Rivers for 90 and 150 miles respectively. It is peopled by a mixed race, Malayan and Papuan, brave and energetic, speaking different dialects, and at war with each other.

The country watered by the Baxter River is low, swampy, covered with forests of mango-trees and thinly populated, contrasting in this respect with the Fly River, which swarms with human beings. The Malayan population of the eastern shore are far above the savage,

and are opposed to the polygamy and cannibalism which exist among the Papuans. The southern peninsula of New Guinea was explored; a range of mountains forms the backbone, running north and south; at a height of 4,000 feet were found dense forests of tropical vegetation, covering the whole northern range except the top of Mount Owen Stanley, which rises in a double peak 13,205 feet. The soil of this region is very rich; sugar-cane, yams, sweet-potatoes, and tobacco, are cultivated; bread-fruit and mango are indigenous. The people have frizzled hair, and are darker than the Malays, differing from them also in disposition, being inoffensive and friendly. "The women take an active part in any disturbance, and were found more capable of making a hard bargain than the men. None of the tribes believe in a God, and attribute everything extraordinary to some supernatural agency.

"The climate of this part of the peninsula is relaxing. It is impossible to live in the valleys without impairing the constitution, from the excessive moisture; but in the interior it is more salubrious. Birds are very numerous, conspicuous among which is the bird-of-paradise, but flowers are scarce. Miclucho Maclay, who has made extensive explorations in New Guinea, was engaged last July in explorations on the northeast side of the island, about Astrolabe Bay, the part of the coast which has been named after him; and he reports that in April an earthquake occurred in the highlands in that vicinity, which destroyed many villages."

The island is 1,400 miles long, and from twenty to 450 miles wide; it possesses great vegetable and mineral wealth, and large portions of it are suitable to European colonization. It may in the future become the seat of an important civilization.

"The islands of the northeast coast of New Guinea have been visited. The natives are nude savages of the Oriental negro type, who live more like beasts than human beings. Cannibalism prevails throughout the islands, not as a religious rite, but as a means of subsistence. The details of this horrible practice are too revolting to repeat. The natives say that there is in the islands a race of human beings with tails, who are not monkeys; that the tail is bony and inflexible, so that those with this caudal appendage have to dig a hole in the sand before they can sit down, as they die if the tail is broken. We have thus revived the account of the men with tails heretofore reported to exist in Borneo and the interior of Africa, but always upon native information, with the exception of hearsay information alleged to have been given by a sailor cast away on the coast of Borneo, and, like all such, of little value."

Exploration has been made of that portion of the Australian Continent lying between Murchison and the Overland Telegraph line. The Ashburton River was traced to its source, thus defining the extent and position of the western water-shed which abuts on the

desert in 120° 20′ east longitude. No water-courses were found flowing to the eastward; along the twenty-fourth parallel to 127° east longitude, the country was found to be an open desert.

"This very imperfect survey of the geographical work of the world, when regarded as the work of a single year, justifies, I think, what I said in my last address—that we are living in a great geographical age."

IS THE MOON A DEAD PLANET?[1]

IT is not a little curious that the great body which for ages has been proverbial for its changeableness should have at last come to be looked upon as the most unchangeable of bodies. When the earth was regarded as constituting the universe, and the heavenly bodies as mere exhalations from it, the moon was, of course, believed to be nothing but a meteor—a great lantern hung in the sky to illuminate and rule the terrestrial night; but, when modern astronomy had established the idea that the earth is but a moving planet, and the planets themselves great orbs like our own globe, speculation inevitably arose in regard to their condition. It was then concluded that the moon may be like the earth, with its oceans, plains, mountains, atmosphere, vegetation, and inhabitants; and this idea long prevailed as a part of the great doctrine of the plurality of worlds. But an opposite opinion at length grew up among astronomers, which has been greatly strengthened in recent years. This change of view has been largely ascribed to the celebrated astronomer Mädler, who made a very forcible statement of the differences and contrasts between the condition of the moon and that of the earth, and pointed out that the current view that the moon may be a copy of the earth is impossible. These views crept into astronomical text-books, and gradually led to the conviction that the moon is a sort of played-out or defunct planet, destitute of air and life—a mere mass of rocks and cinders, cold, lifeless, and unchangeable.

But although this view is still current among astronomers in general, there is a class of astronomers (selenographers, as they are called) who have studied the lunar surface with long and profound attention, and to whom we are indebted for our present knowledge of our satellite, who hold a different view. They agree in the belief that many processes of actual lunar change are in progress, and they have detected the existence of a lunar atmosphere. This conflict of opinion is said to be due to the fact that the labors of selenographers are in-

[1] Abridged from an article in the *Quarterly Journal of Science*, entitled "Physical Changes upon the Surface of the Moon," by Edmund Neisan, F. R. A. S., author of "The Moon, and the Condition and Configuration of its Surface."

accessible to most astronomers, and are hence but imperfectly known. The inquiry, we are told, is one of great difficulty, requiring a thorough acquaintance with several branches of science. The results arrived at by prolonged, minute, and careful observation of the details of the lunar formation are rejected because the proofs on which they rest are not well understood.

The most prominent instance of supposed lunar change on the surface of the moon is that of the crater Linné. On the northwest quadrant of the moon, near the centre of a level tract about 430 miles in diameter, there is a bright crater called Bessel, nearly 14 miles in diameter, with a circular wall rising 4,000 feet above the interior, and about 1,600 feet above the surrounding plain. Scattered over this plain are a few small craters, some 2½ miles in diameter, with walls about 300 feet high. Near its eastern centre an eminent selenographer named Lohrman placed a distinct, bright crater about five miles in diameter, which he described as being, after Bessel, the most conspicuous object on this great tract of level ground. Ten years later, our greatest selenographer, Baron von Mädler, confirmed Lohrman's observations, and made this crater a subject of special study, naming it Linné. In the drawings of Schmidt, who was about this time making lunar observations of this particular part of the moon, Linné is shown as a deep crater corresponding with the descriptions of Lohrman and Mädler.

In October, 1866, when Linné was in a position to be most conspicuous, Schmidt was startled by finding no trace of the deep, wide crater, but only a faint cloud marking about five miles in diameter. Schmidt at once announced the circumstance, and nearly every astronomer in Europe turned his attention to the spot. But Linné has never since been seen of the size and character given it by Lohrman, Mädler, and Schmidt. This large crater unquestionably no longer exists. Powerful telescopes reveal, in its place, a white, cloudy marking containing a small crater-cone with an opening scarcely one-twentieth the size of the former crater.

The reason why astronomers will not admit the reality of any change in Linné is, first, a strong prejudice against the possibility of such change; and, second, the fact that Schröter, of Lillienthal, the earliest of the great selenographers, in one of his first drawings, made November 5, 1788, with low powers, does not draw Linné as a crater. Near its place he draws a white spot on a ridge marked V, and a larger spot marked G. Schmidt took this white spot to be Linné, a view strongly urged by Huggins, and accepted as correct by astronomers. They say, as Schröter's drawing is not unlike the present appearance of Linné, Lohrman, Mädler, and Schmidt, must have been mistaken as to what they thought they saw. Again, in a map made by Lahire in the seventeenth century, no trace of Linné can be found. It may be said, however, that all the maps of this period

omit numerous craters far larger than Linné. They were principally full-moon drawings, where Linné would not be visible as a crater. Riccioli's map, however, shows Linné as a distinct crater. But the present crater on the site of Linné could not possibly have been seen by Riccioli with the optical means at his command.

In every other instance of discrepancy between the drawings of Schröter, and Beer, and Mädler, Schröter's are rejected, while in this particular case one of Schröter's earliest drawings, made with imperfect instruments, is brought forward to prove the incorrectness of his great successors.

It will require long study of this region with powerful telescopes to determine the nature of the change undergone by Linné. From numerous observations the explanation agreeing best with the present condition of the surface is, that the walls of the old crater have collapsed and fallen into the interior. In this way the interior would be almost entirely filled up, leaving a rough, cone-like crater in the centre. Under favorable conditions, with a powerful telescope, the surface immediately around the small crater appears rough and irregular. Round the border of the old crater are numerous mounds and blocks, and on the east, one or two peaks or low hills, seeming like portions of the old wall. The difficulty of making these observations is very great, and they are only possible in the finest atmospheric conditions.

Proctor has tried to show that the changes in Linné are variations of tint due to differences of illumination. But no selenographer will admit that any alteration whatever in illumination could make an object where Linné is placed, look at one period like a considerable and deep crater, and at another as a small, scarcely visible crater.

The facts about Linné may be therefore summed up very briefly. According to three or more independent selenographers, the most experienced that science has seen, the object named Linné was a conspicuous crater of large diameter and great depth. Now, in its place all that exists is a tract of uneven ground, containing a small, scarcely visible, insignificant, crater-like object. It is impossible that one could ever be systematically taken for the other. It is inconceivable how our three greatest selenographers could have systematically and independently made the same blunder, and that one blunder only. For in no other case do we find any error of this nature. Their description must, therefore, be held to truly describe the nature of the formation at their epoch (1820–'45). The object is no longer of the same size and description. A real physical change on the moon's surface must therefore have occurred at this point. This, then, is the conclusion that selenographers as a body have arrived at; yet, despite the strong evidence on which it rests, it is not generally recognized by astronomers.

The next instance of change on the surface of the moon is that of

the crater named Messier by Beer and Mädler. In its equatorial region, on the westernmost of the great lunar plains, close to one another, are two small crater-plains about nine miles in diameter, surrounded by very low ridges and mounds and crater-like depressions. These two formations, named Messier and Messier A, were discovered and described by Schröter, who regarded Messier as slightly the larger. Beer and Mädler examined these formations most carefully on more than three hundred distinct occasions between 1829 and 1837. They declared that the two crater-plains were exactly alike in every particular. Both were circular and of the same size, with bright, grayish-white walls and a yellowish-gray interior. The walls were of the same height, with wall-peaks situated in the same relative position. In diameter, form, height of walls above the surrounding surface, and depth and color of the interior of the walls, Beer and Mädler declared that they were completely alike. Some years after this, a slight dissimilarity between the forms of the two craters was noticed, and in November, 1855, the Rev. T. W. Webb, one of the best living lunar observers, discovered that the eastern crater-plain, Messier A, appeared the larger of the two.

In March of the following year he observed that not only was Messier the smaller, but that it was elliptical. He confirmed these observations on repeated occasions, and in 1857 made drawings showing Messier A unchanged, while Messier had an elliptical form, with a long diameter of about 10 or 11 miles and a short diameter of about $7\frac{1}{2}$ to 8 miles. The matter attracted little further attention until 1870 to 1875. During these years Messier and Messier A were studied with the aid of powerful telescopes, and during the past year the long diameter of Messier appears to be 12.2 miles and the short diameter 6.9. The difference between the form and dimensions of these two formations is now obvious in the smallest astronomical telescope. It is inconceivable that Beer and Mädler could have failed to recognize these differences with their fine Fraunhofer equatorial, with which, on hundreds of different occasions, they carefully scrutinized them in search of differences.

This slow squeezing out of shape of an immense crater-plain is a change that seems to defy explanation. Nothing analogous now exists on the surface of the earth, and it is not surprising that there should be a strong reluctance to admit that such a change has occurred. A careful examination of Messier and its neighborhood, however, suggests that, instead of a bodily compression of the entire crater, there has been a gradual sliding of the north and south walls into the interior, and a pushing of the entire western wall outward and westward down an incline existing there. Selenographers could point to a hundred cases where a like circumstance has occurred. As far as is at present known, this explanation accords with the condition of the formations around Messier, but further observations with

powerful telescopes are indispensable. Unfortunately, it is a difficult matter to study, for on only one or two days in the year is Messier likely to be found in a proper condition to be observed.

Other instances of change in the lunar surface have been detected by selenographers, but the evidence on which they rest is not so overpowering as is needed to induce their acceptance.

Periodical variations in the color and brightness of lunar regions, such as would result from processes of vegetation, were first noticed by Beer and Mädler, but they regarded the absence of masses of water upon the moon as a fatal objection to this explanation. The variation in the floor of Plato is one of the most interesting of these changes. Plato is a circular plain 60 miles in diameter, surrounded by a belt of highlands from 3,000 to 3,500 feet in height. These highlands at sunrise are a pale yellowish gray, gradually changing to grayish white. At sunrise the interior of Plato appears of a cold gray, but, as the sun rises higher above the horizon of Plato, and the solar rays fall more perpendicularly on this region, the whole surface grows rapidly brighter, until, about two days after sunrise, the interior of the formation attains its brightest tint. It is then a cold, light yellow gray, often approaching a pale yellow, in fact, and brighter than the surface of the Mare Imbrium on the north, while the surrounding highlands are a bright grayish white, tinted here and there with gray. Judging from what occurs in any of the numerous other formations resembling Plato, this may be considered the normal tint, inasmuch as those other formations which present exactly the same phenomena up to this time, and which, under similar conditions, present exactly the same appearance, retain this tint unaltered until near sunset. After, however, the second day, the floor of Plato commences to undergo a most extraordinary and anomalous change, which renders it unique on the moon, for, instead of growing lighter, the interior commences to become darker. Four days after sunrise it is materially darker than the northern Mare, and a cold gray in tint, while the surrounding highlands are a bright white in color, tinted with gray; the appearance they retain until the thirteenth day after sunrise, growing a little, though not very much, brighter toward full moon. Two days later the floor of Plato has become a dark gray; at full moon it is deep steel-gray; and, about two days after full, reaches its darkest tint, a very deep steel-gray, almost approaching a black color. Under these conditions, it is one of the very darkest portions of the entire lunar surface, though, seven days prior, it was one of the lightest portions of the surface of its kind. After this, it gradually lightens in tint, but much slower, and never reaches so light a tint.

This extraordinary periodical change in the tint of the floor of Plato has hitherto received no explanation, but its existence has been put beyond the pale of doubt, and Mr. Birt has, at the instance of a British Association Committee, carefully discussed a numerous series

of observations, made in the years 1869, 1870, and 1871, by six or seven independent observers.

Proctor has attempted to show that these appearances are the effect of contrast. Thus, at sunrise, the floor of Plato is thrown against a dark background, due to the sombre, barely-illuminated surrounding regions; while at full moon it has for a background the brilliantly-illuminated surrounding highlands, and should look much darker. But if the great darkening observed to occur in the tint of the interior of Plato is merely apparent, and only what must occur when a darkish walled plain is surrounded by a bright background, or, rather, bright environs—and this is all Mr. Proctor ascribes to it—it must be a perfectly normal occurrence, and the same must take place in every similarly-placed formation, unless that has something anomalous about it to prevent this taking place. All selenographers could instance a number of such walled plains where no such darkening occurs. Are we, then, to assume that these plains possess anomalously constituted interiors, and that only Plato, of all the lunar formations, exhibits the normal phenomena? This is, of course, entirely inadmissible, and selenographers are thoroughly aware that the effects of contrast alluded to by Mr. Proctor are entirely incapable of bringing about such an immense darkening in tint as is apparent in the case of the floor of Plato.

The reason of this singular darkening in the floor of Plato is not yet understood. Selenographers believe that it results from an actual change due to the heating action of the solar rays. But the further elucidation of the subject requires special observations with special appliances. Thus, as in so many selenographical problems, patient observation establishes the existence of certain phenomena, but the elucidation of the meaning of the phenomena established is checked for want of special observations that are never made. For these, selenographers have to appeal to those astronomers devoted to what has been termed astronomical physics, but they are too much engaged on more fascinating subjects to give attention to such inquiries.

The instances here dealt with will show that selenographers are not without strong evidence in favor of the opinion that has long been unanimously held by them, that processes of change are still actively at work upon the moon. It must not, however, be supposed that the above are the sole instances which they have recognized, because this is by no means true, only the difficulties in establishing others have led to their omission here. Dealing with a subject such as selenography, it is only those who are familiar with all its details who properly appreciate the evidence in favor of or against its problems. The difficulties in the way of making the true bearings of selenographical questions properly understood are greater than might be imagined; for even the very elementary fact that volcanic changes such as are now active on the earth would not be recognizable on the moon, in

the present state of our acquaintance with the configuration of its surface, is not generally understood. When, however, the attention of astronomers is more generally directed to the study of the lunar surface, Science will be greatly the gainer, as it is there that the past and future of our earth is to be learned.

SIZE OF THE PRINCIPAL TELESCOPES IN THE WORLD.

IN *Les Mondes*, January 20, 1876, appeared a list of the principal telescopes of the world, with their apertures and focal lengths. It was defective in regard to its enumeration of American telescopes, and in other respects, as all such lists must be. We have compiled from it, and from other sources available, a larger list, which is itself manifestly incomplete, but which will give a better idea of the number of telescopes available, or soon to be available, for astronomical purposes. It is a melancholy fact that the return from so many instruments, that is, the interest from so much astronomical capital, is not so great as it should be, and it suggests the question as to whether future benefactors of American colleges, for example, will not do better to provide astronomers to use the telescopes already constructed than observatories in which to put new ones. In the second column, the first name is that of the maker of the objective or speculum, the second that of the engineer who mounted the telescope.

I. REFLECTORS.

One French inch = 12 Paris lines; one English inch = 11.26 Paris lines; one metre = 443.30 Paris lines.

OWNER OR DIRECTOR, AND OBSERVATORY.	Constructed by	APERTURE.			FOCAL LENGTH.			REMARKS.
		English Inches, etc.	French Inches.	Metres.	English Feet, etc.	French Feet, etc.	Metres.	
Lord Rosse, Birr Castle.	Rosse.....	6 ft.	.....	.....	55 ft.	.....	.....	
Wm. Herschel, Slough ..	W. Herschel....	4 "	.....	.....	40 "	.....	.....	Out of use.
Lassell, Liverpool, etc...	Lassell.....	4 "	.....	.....	37 "	.....	.....	Destroyed.
Ellery, Melbourne.....	Grubb.....	4 "	.....	.....	32 "	.....	.....	
Le Verrier, Paris.....	Martin, Eichens.	.....	.....	1.20	.....	.....	7	Silvered glass.
Lord Rosse, Birr Castle..	Rosse	36 in.	.....	.....	.....	.....	.....	
Tisserand, Toulouse.....	Foucault.....	.....	.....	0.80	.....	.....	.....	Silvered glass.
Stephan, Marseilles.....	Foucault, Eichens.....	.....	.....	0.80	.....	.....	4.80	Silvered glass.
H. Draper, near N. York.	H. Draper	28 in.	.....	.....	18 ft.	.....	.....	Silvered glass.
Lassell, Maidenhead.....	Lassell	24 "	.....	.....	20 "	.....	.....	Metal.
W. & J. Herschel, Slough, and Cape Good Hope..	W. & J. Herschel	18 "	.....	.....	20 "	.....	.....	Several mirrors.
H. Draper, near N. York.	H. Draper.....	15 "	.....	.....	.....	.....	.....	
Maclean, Tunbridge Wells	With & Browning	15 "	.....	.....	.....	.....	.....	
Pritchard, Oxford.....	De la Rue	13 "	.....	.....	10 ft.	.....	.....	
Worthington and Baxendell, Manchester	With & Browning ?	13 "	.....	.....	.....	.....	.....	
Hirst, New Zealand.....	Browning.....	8½ "	.....	.....	.....	.....	.....	Silvered glass.

and many others.

II. Refractors.

Owner or Director, and Observatory.	Constructed by	Aperture.			Focal Length.			Remarks.
		English Inches.	French Inches.	Metres.	English Ft. and Inches.	French Ft. and Inches.	Metres.	
Lyman, Yale College	A. Clark & Sons.	28	.....	.....	.....	.....	.....	Constructing.
Littrow, Vienna	Grubb	27	.....	.....	.....	.....	.....	Constructing.
McCormick, ?	A. Clark & Sons.	26¼	.....	.....	33 ft.	.....	.....	
C. H. Davis, Washington	A. Clark & Sons.	26	.....	.....	390 in.	.....	.....	
Newall, Gateshead	Cooke	25	.....	.....	29 ft.	.....	.....	
Buckingham, London	Buckingham	21	.....	.....	.....	.....	.....	
University of Chicago	A. Clark & Sons.	18.5	.....	.....	23 ft.	.....	.....	
Winnecke, Strasburg	Merz	.....	18	.....	.....	.....	.....	Constructing.
Pickering, Harvard Coll.	Merz	15	.....	.....	23 ft.	.....	.....	
O. Struve, Pulkova	Merz	14.93	.....	.....	270.6	.....	.....	
Lord Lindsay, Dun Echt	Grubb	15	.....	.....	15 ft.	.....	.....	
Huggins, London	Grubb	15	.....	.....	.....	.....	.....	
Downsede College, Bath	.....	14.5	.....	.....	.....	.....	.....	Destroyed by fire in 1867.
Cooper, Markree Castle	(?)	14	.....	.....	25 ft.	.....	.....	
Oom, Lisbon	Merz	.....	14	.....	.....	.....	.....	
C. H. F. Peters, Clinton	Spencer	13.5	.....	.....	16 ft.	.....	.....	
Boss, Albany	Fitz	13	.....	.....	182 in.	.....	.....	
Rutherfurd, New York	Rutherfurd	13	.....	.....	.....	.....	.....	Photographic.
Langley, Pittsburg	.....	13	.....	.....	.....	.....	.....	
Watson, Ann Arbor	Fitz	12.5	.....	.....	17 ft.	.....	.....	
Airy, Greenwich	Merz & Simms	12.5	.....	.....	16.6	.....	.....	
Mitchell, Vassar College	Fitz, reworked by Clark	12.38	.....	.....	.....	.....	.....	
Pritchard, Oxford	Grubb	12.25	.....	.....	.....	.....	.....	
Pritchett, Glasgow, U. S.	A. Clark & Sons.	12.25	.....	.....	17 ft.	.....	.....	
Le Verrier, Paris	Secretan & Eichens	.....	12	.....	.....	.....	5	
Littrow, Vienna	A. Clark & Sons.	12	.....	.....	.....	.....	.....	
Adams, Cambridge	Cauchoix	12	.....	.....	20 ft.	.....	.....	
Ball, Dublin	Cauchoix	12 ?	12 ?	.....	.....	.....	.....	
H. Draper, near N. York	A. Clark & Sons.	12	.....	.....	.....	.....	.....	
Main, Oxford	Cauchoix	12 ?	12 ?	.....	.....	.....	.....	
Pritchard, Oxford	Grubb	12	.....	.....	.....	.....	.....	
Le Verrier, Paris	.....	.....	.....	0.32	.....	.....	.....	
White, Brooklyn	Fitz, reworked by Clark	11⅞	.....	.....	.....	.....	.....	
Stone, Cincinnati	Merz	11.5	.....	.....	17 ft.	.....	.....	
V. Bülow, Bothkamp	Schroeder	.....	11	.....	.....	16	.....	
Lamont, Munich	Merz	.....	10.5	.....	.....	15	.....	
Schjellerup, Copenhagen	Merz	.....	10.5	.....	.....	15	.....	
Gould, Cordova	Fitz	11.25	.....	.....	14 ft.	.....	.....	Photographic.
Van Vleck, Middletown, U. S.	A. Clark & Sons.	11	.....	.....	.....	.....	.....	
——, Florence	Amici	.....	11	.....	.....	.....	.....	
Oom, Lisbon	A. Clark & Sons.	11	.....	.....	.....	.....	.....	Photographic.
Rutherfurd, New York	Rutherfurd and Fitz	.....	10.5	.....	.....	.....	.....	Photographic.
D'Aguilar, Madrid	Merz	.....	10	.....	.....	.....	.....	
Brodichin, Moscow	Merz, reworked by Clark	.....	10	.....	.....	16	.....	
Michie, West Point	Fitz, reworked by Clark	10	.....	.....	14 ft.	.....	.....	
Stephan, Marseilles	Eichens	.....	.....	0.25	.....	.....	8	
Barclay, Leyton	Cooke	10	.....	.....	12 ft.	.....	.....	
Fletcher, Cumberland	.....	10	.....	.....	12 "	.....	.....	
——, Dorpat	Fraunhofer	9.62	.....	.....	.....	14	.....	
Förster, Berlin	Merz	9.62	.....	.....	.....	14	.....	
Secchi, Rome	Merz	9.62	.....	.....	.....	14	.....	
Tacchini, Palermo	Merz	9.62	.....	.....	.....	14	.....	
Kowalski, Kazan	Merz	9.62	.....	.....	.....	14	.....	
C. H. Davis, Washington	Merz, reworked by Clark	9.62	.....	.....	.....	.....	.....	
Lefont, Calcutta	Steinheil	9.62	.....	.....	172 in.	.....	.....	
Pogson, Madras	Lerebours and Secretan	9	9 ?	.....	.....	.....	.....	
Buckingham, London	Secretan	9	9 ?	.....	.....	.....	.....	
Young, Dartmouth	A. Clark & Sons.	9.38	.....	.....	12 ft.	.....	.....	
Grant, Glasgow	.....	9	.....	.....	.....	.....	.....	
Crossley, Halifax	Cooke	9.33	.....	.....	.....	.....	.....	
Edgecomb, Hartford	A. Clark & Sons.	9.4	9	.....	.....	.....	.....	
Schultz, Upsala	Steinheil	.....	.....	.....	.....	.....	.....	
Barneby, Worcester	Cooke	9	.....	.....	.....	.....	.....	
Bruhns, Leipsic	Steinheil, Pistor	.....	8	.....	.....	12	.....	
Menten, Quito	Merz	.....	9	.....	.....	117	.....	

II. REFRACTORS—(*Continued*).

OWNER OR DIRECTOR, AND OBSERVATORY.	Constructed by	APERTURE.			FOCAL LENGTH.			REMARKS.
		English Inches.	French Inches.	Metres.	English Ft. and Inches.	French Ft. and Inches.	Metres.	
Stonyhurst College		8						
Wilson, Rugby	A. Clark & Sons.	8.25						
——, Florence	Amici		8					
Erck, Ireland	A. Clark & Sons.	8				75 in.		
Ashe, Quebec	A. Clark & Sons.	8				9 ft.		
Hartnup, Liverpool	Merz	8			12 ft.			
Lyman, Yale College		8.25						
U. S. Naval Academy	A. Clark & Sons.	7.75						
Esty, Amherst College	A. Clark & Sons.	7.25			101 in.			
Bishop, London	Dollond	7			11 ft.			
Knott, ——	A. Clark & Sons.	7.33			9.4			
Birt, London		7.5						
Leeson-Prince, ——	Tulley	7			12 ft.			
Russell, Sydney	Merz	7			9.66			
Main, Oxford	Repsold	7.5			10.5			Heliometer.
Williams College, U. S.	A. Clark & Sons.	7⅛						
——, Naples	Fraunhofer		7					
O. Struve, Pulkova	Merz		7					Heliometer.
(Col'ge), Shelbyville, U.S.	Merz		7		10 ft.			
Hansteen, Christiania	Merz		7					
Kaiser, Leiden	Merz		7					
Dembowski, Florence	Merz		7					
Russell, Sydney	Merz		7					
Luther, Königsberg	Fraunhofer and Merz		70.2 l.			1,184 l.		Heliometer.
——, Capstadt	Merz		6.5					
Wendell, Bates College, U. S.	A. Clark & Sons.	6.25						
Moore, Lynn, U. S.	A. Clark & Sons.	6.25						
Burnham, Chicago	A. Clark & Sons.	6						
Lee, Hartwell	Tulley	6						
Lockyer, London		6.25			8.5			
Monckhoven, Genth	Cooke	6			7.5			
Lord Lindsay, Dun Echt.	Cooke	6			6			
——, Madras	Dollond	6?			5			
Wolf, Zürich	Dollond	6	6?			8		
Schmidt, Athens	Dollond	6	6?					
Schoenfeld, Bonn			6					Heliometer.
Moesta, Santiago	Young, Fitz		6.4			103.7		
High School, Philadelphia	Merz		6			8 ft.		
Trouvelot, Cambridge	Merz		6			8.5?		
Peek, Columbia College	A. Clark & Sons.	6						
Durham University	Ross	5						
——, Lucknow	Troughton	5.5						
Broun, Trevandrum	Dollond	5			7.5			
U. S. Transit Venus Com.	A. Clark & Sons.	5			5 ft.			8 instruments.
Loomis, Yale College	Dollond	5			10 "			
Curley, Georgetown	Simms	5			80 in.			
Pickering, Harvard Coll.	Merz		4		5 ft.			
Luther, Bilk			4					
Tebbutt, New S. Wales		4.5						
Bruhns, Leipsic				0.117			1.96	
Lord Lindsay, Dun Echt.	Repsold		4					Heliometer.
Carrington, Red Hill	Simms	4.5			4.3			

and many others.

THE JOURNEYINGS AND DISPERSAL OF ANIMALS.

IN his recent elaborate work on the "Geographical Distribution of Animals," Mr. Alfred Russel Wallace gives much attention to the subject of migrations as among the means of dispersion, and from his copious treatment of the subject, and various other sources, we glean the following brief particulars upon this subject:

Winged *insects* are perhaps, of all, most admirably adapted for the special conditions found in one locality, and the barriers against their permanent displacement are numerous. Thus many insects require for their subsistence succulent vegetable food during the entire year, which, of course, confines them to tropical regions; some are dependent on mountain-vegetation; some subsist on water-plants; and yet others, as the *Lepidoptera*, in the larva state, are limited to a single species of plant. Insects have enemies in every stage of their existence; foes are at hand ready to destroy not only the perfect form, but the pupa, the larva, and the egg; and any one of these enemies may prove so formidable, in a country otherwise well adapted to them, as to render their survival impossible. But, on the other hand, most varied means of dispersal carry insects from their natural habitats to distant regions. They are often met far from land, carried thence by storm or hurricane. Hawk-moths are sometimes captured hundreds of miles from shore, having taken passage on ships which neared tropical countries, and Mr. Darwin narrates that he caught in the open sea, seventeen miles from the coast of South America, beetles, some aquatic and some terrestrial, belonging to seven genera, and they seemed uninjured by the salt-water. Insects, in their undeveloped states, make their abodes in solid timber, which, transported by winds and waves, may carry its undeveloped, winged freight great distances. Tropical insects are not unfrequently captured in the London docks, where they have been carried in furniture or foreign timber. Insects are very tenacious of life, and nearly all can exist for a long time without food. Some beetles bear immersion in strong spirit for hours, and are not destroyed by water almost at the boiling-point. These facts enable us to understand how not only by means of its delicate wings, but by winds, waves, volcanic dust, and a thousand other agencies, insects may be carried to remote regions.

Mollusca, which are less highly organized than insects, have, of course, limited appliances for journeying, and their dispersal and distribution may involve long periods of time. Fresh-water mollusks are very widely distributed, and this is accounted for by Mr. Darwin by the fact that ponds and marshes are frequented by wading and swimming birds. These carry away with them the seeds of plants and the eggs of mollusks. True land-shells are exceedingly sensitive to salt-water, and yet they are found all over the globe. Experiments on their power to resist sea-water show that a membranous diaphragm, which they sometimes form over the mouth of the shell, enables them to survive many days' immersion in it. They may lie dormant for a long time, some having lived between two and three years shut up in boxes; and one snail, from the Egyptian Desert, was found to be alive after having been glued for four years to a tablet in the British Museum. These facts render it quite possible that they may cross the

sea in the chinks of drift-wood, and this is probably the means of their dispersal.

The inhabitants of the sea seem to have unlimited facilities for journeying, but when we remember that cold water is essential to many fishes, tropical warmth to others, and the deep sea an effectual barrier to a large number of species, it is apparent that the Atlantic may be as impassable a gulf to fishes as to land-animals. Distinct river systems are sometimes inhabited by the same species of fresh-water fish, which indicates that they have some means of dispersal over land. This may be accomplished by changes of level giving rise to altered river-courses and new water-basins, to transportation of the eggs by ducks, geese, aquatic birds, and even water-beetles, and to the agency of whirlwinds and hurricanes, which carry up considerable quantities of water, and with it small fishes.

Reptiles have very limited means of dispersal. Snakes are dependent on climate, being comparatively scarce in temperate and cold regions. They entirely cease in 62° north latitude, and are not found above 6,000 feet on the Alps. They swim rivers easily, but, since they are rarely met on oceanic islands, it is inferred that they have no means of crossing the sea. Lizards are also tropical animals, though they are found higher on the mountains and farther north than are snakes. They possess some means of crossing oceans, and frequently inhabit islands where there are neither snakes nor mammalia. The amphibia extend farther north than true reptiles, frogs being found, sometimes, beyond the arctic circle. Salt-water is fatal to them, and they are probably effectually limited by deserts and oceans.

It would seem, at first, that birds are limited by no barriers, and that a study of their habits could scarcely throw any light upon the causes of animal distribution; but remarkable contrasts in the extent of their range are presented by different groups of birds. Thus, the gulls (*Laridæ*) and petrels (*Procellaridæ*) are great wanderers, a few being found, with scarcely any variation, over almost the entire globe; other species being restricted to one of the great oceans; while parrots, pigeons, and many small perching birds, are confined to islands of limited extent, or to single valleys or mountains. Some birds, such as the apteryx, ostrich, and cassowary, have no power of flight, and, of course, limited means of dispersal. The short-winged birds, such as wrens and toucans, are able to fly but a short distance, and only species endowed with great powers of flight can cross extended widths of sea. Violent gales sometimes carry small birds accidentally to foreign countries, as is shown by the large numbers of North American stragglers which reach the Bermudas. Inadequate supply of food, afforded by the vegetation of a country, oceans, and even large rivers, may serve as effectual barriers to the dispersal of birds. The presence of enemies, of either the young, the eggs, or the parent-birds, may limit the range of a species. In the Malay Archipelago pigeons are

said to "abound most where monkeys do not occur, and in South America the same birds are comparatively scarce, in the forest-plains, where monkeys are very abundant, while they are plentiful on the open plains and *campos*, and on the mountain plateaux, where these nest-hunting quadrupeds are rarely found." When we consider that the pigeon is the most careless and awkward of birds in the construction of its nest, it is not difficult to understand how formidable an enemy it must have in the artful and wary monkey.

The term migration is strictly applied to the annual movements of birds and fishes, which take place in large bodies, and are immediately connected with the process of reproduction. In all temperate regions a large number of birds reside temporarily. Some arrive in spring, and leave in autumn; others arrive in autumn, remain during the winter, but depart in spring; and yet others, birds of passage, pass through the country twice a year, without long delay. The species which winter here are those which build their nests and rear their young farther north, and in returning, on the appearance of spring, they simply act as do those whose homes are nearer the equator. The birds of passage, like our winter-birds, have their breeding-quarters nearer the poles, but, like our summer-birds, seek a warmer climate for the winter. The arrival of migratory birds from warmer regions seldom varies more than a week or two, though their departure is more dependent on the weather, and consequently less constant.

The migratory birds of Europe seem to have a definite route: they "go southward to the Mediterranean, move along its coasts east or west, and cross over in three places only—either from the south of Spain, in the neighborhood of Gibraltar, from Sicily, over Malta, or to the east by Greece and Cyprus." The passage is mostly accomplished by night, and is undertaken only when there is a steady wind from the east or west, and when there is moonlight. It is an interesting fact that the males often leave before the females, and both parents before their offspring; the latter, however, rarely go so far as do the old ones. On returning they vary their course, some following the old, others adopting a new line of travel. In connection with the routes taken by European birds, it is suggestive and interesting to note that fossil remains of huge animals, and the shallow waters in this part of the Mediterranean, indicate that Gibraltar, Sicily, and Malta, must have been at no very distant date united with Africa; the submersion of this land involved considerable time, and the change could hardly have been perceptible from one year to another. It is natural to conclude that the migration, which was at first a land-passage, would be kept up over marshes, then over a channel, and finally over the sea. The sea-passage is a dangerous one for birds, and, from the immense flocks of quails which annually undertake it, large numbers are drowned when the weather proves unfavorable for the passage.

The migratory movement of the North American birds is almost wholly limited to the Atlantic coast, a smaller number being permanent residents than on the Pacific coast, or in corresponding European localities. In Massachusetts the regular number of summer visitors is 106, while there are only 30 species which remain all the year. The number of permanent residents increases as we go southward, but during the breeding-season in any single locality it increases as we go northward until we reach Canada, where more species rear their young than in the Southern States. The extent of the migration of certain birds has greatly altered within a limited period of observation. A Mexican swallow (*Hirundo lunifrons*) first appeared in Ohio in 1815; its yearly range increased, until in 1845 it had reached Maine and Canada, and now its annual migrations extend to Hudson's Bay. The rice-bird, or "bobolink," enters the Southern States in April, passes northward until in June it reaches Canada, and stops in its westerly course at the Saskatchewan River, in 54° north latitude, having widened its range continually as wheat and rice were cultivated over more extensive areas.

A nocturnal concourse of birds sometimes occurs in the neighborhood of large towns near the end of summer, in still, cloudy weather. The notes of well-known birds may be recognized by the skillful ornithologist, at one time faint in the distance, at another near by, while occasionally the stroke of a wing gives a sense of nearness to these remarkable visitors. It is supposed that these noises proceed from migratory birds which, having lost their way, are attracted by the light from street-lamps.

It is thus obvious that the migration of birds is no mere arbitrary matter, but is governed by laws susceptible of intelligent interpretation. Want of food is the most evident cause of their journeyings. As it becomes scarce near the end of summer in the extreme northern limits, those individuals which feel the pressure of want seek it elsewhere, and, in doing so, they press upon the haunts of other birds, until the movement which began in the north has extended to the southern limit. The power of flight in birds makes it possible for them to cross a moderate breadth of sea and unlimited extent of country, and, traveling as they do, mostly at night and high in the air, their movements seem mysterious, simply because they are difficult to observe. But, let us map their comings and goings faithfully as we may, there yet remains the unanswered question, How do these little visitants find their way so unerringly from one place to another, over great distances and apparently unexplored routes?

Some of the largest *Mammalia* are not stopped by any physical obstacle in their journeys over whole continents. The rhinoceros, the lion, and the tiger, have great powers of dispersal, and their possible range is unlimited wherever there are land and sufficient food. The elephant climbs to mountain-tops, difficult of ascent for man, crosses

rivers, and finds its way through the densest jungles. Other groups are much more limited in their wanderings, as witness the monkeys, lemurs, and apes, animals so strictly adapted to an arboreal life that they cannot roam far beyond forest limits. Equally essential to the existence of others is the desert or open country. The range of many mammals appears to be limited by climate, or by its resulting vegetation. Thus the *Quadrumana* are chiefly found within an equatorial belt of 30° wide, but these animals live almost exclusively on fruit, which is the abundant product of the tropics. The polar bear and walrus, which, in a natural state, are limited by the frozen ocean, in confinement may live in temperate regions; the tiger, once regarded as a purely tropical animal, now has his permanent home in Mantchooria, a country of almost arctic climate; and, in post-Tertiary times, the elephant and rhinoceros roamed over the northern continents, even to regions beyond the arctic circle. Hence it does not follow that animals, which we now see inhabiting extremely warm or extremely cold climates, may not, under changed conditions, thrive equally well elsewhere.

Valleys and rivers often prove effectual barriers to mammals. Thus, in the plains along the Amazon, many species of insects, birds, and monkeys, are found extending to the river-bank on one side, which do not cross to the other. And on the northern bank of the Rio Negro there are found two monkeys, the *Brachiurus couxion* and the *Jacchus bicolor*, which are never seen on its southern bank. Many mammals can swim well for short distances, but none over any great extent of sea. It is not unusual for the bear and bison to swim across the Mississippi, and from Lyell's "Principles of Geology" we learn that in 1829, during the floods in Scotland, pigs six months old, which were carried to sea, swam five miles back to shore; and it seems entirely probable that wild-pigs, from their greater activity and power of endurance, might cross arms of the sea twenty or thirty miles wide, and facts in the distribution of these animals lead us to infer that they have sometimes done so. Lemmings, rats, and squirrels, often migrate in enormous bands, but they generally perish in the sea-water. And, admitting that many mammals have power to swim considerable distances, it remains true that a channel ten or twenty miles wide would, in most cases, prove an effectual barrier to them. The bats, provided as they are with wings, and the *Cetacea*, which swim, have exceptional powers of dispersal. In the arctic regions glaciers give rise to icebergs; these descend to the sea, often carrying with them masses of earth and some vegetation. Such arctic quadrupeds as frequent the ice, as well as occasionally true land-animals, might often be carried from place to place in this way. But the uprooted trees and rafts of drift-wood which float down large rivers and out to sea, are more effectual agents in the dispersal of animals. Such islands or rafts are sometimes seen drifting hundreds of miles from

the mouth of the Ganges, bearing upon their surfaces erect, living trees. And the Amazon, Orinoco, and in fact most large rivers, present at times similar spectacles. Here, then, is most ample opportunity for carrying all small arboreal animals out to sea, and, although they are liable to perish, unusual tidal currents may bear them great distances safely from their native country.

THE EARLY MAN OF NORTH AMERICA.[1]

By A. R. GROTE,
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A CHILD is not fully formed in body or developed in mind when it is born. It behaves at first without experience. That is the reason we do not always understand baby when it "acts so." Our own behavior is the result of our experience. Baby moves its hands and twists its legs without knowing why. But it gradually selects from among these movements those which are found to satisfy its wants, and in the future performs such actions only. It uses its voice in the same way, as shown by Taine and other writers, gradually picking up such words as it finds are answered. Again it acquires, always by experience, the idea of distance. The moon seems so near that the child wants it taken down to play with; while the position of objects close at hand is equally misjudged. And so with the senses of hearing, smelling, tasting, and feeling.

It does not know at first where the pin is that pricks it; and, even if we slap it on the very part recommended by Dr. John Brown for the purpose, baby will not be able to locate the injuries, though it may have a general sense of discomfort, and resent the injustice in its feeble little way. Just as it passes through a process of self-education by experience, its mind receives constant correction as to the nature of surrounding objects. Baby's principal opinion at one time is, that inanimate things possess like feelings and properties with itself. This idea of baby's we sympathize with when we pick up a chair over which it has stumbled in its efforts to walk, and pretend to whip "that naughty chair," until baby stops its crying and is propitiated by the supposititious sufferings of the chair. This personification of objects is less and less obtruded as the baby grows and becomes better acquainted with the nature of its surroundings. But it is hardly ever entirely dropped, even in after-life, when it becomes in us transferred to matters beyond the reach of our knowledge. These observations on our children become important when we study the actions of races of men less cultured than our own. We find such

[1] A lecture delivered under the auspices of the Buffalo Society of Natural Sciences.

races using their hands to less advantage, as well as other bodily organs, the seats of the senses.

Savages exercise their minds less, and personify more than we do. Like children, they say more readily *no* than *yes* to all questions affecting their bodily advantage. They are afraid of change. All children and all savages are conservative. The savage has not passed the mental state of our own children. It is impossible for a child to conceive of any change in the world outside until it has had some experience of such changes and has reflected upon them. Even then it is hard for the child to understand the appearance of this city of Buffalo, for instance, ten years before the time when its mind first received permanent impressions. It is from this fact that youth appears so long when we look back upon it, as well as from the fact that our early impressions made upon the "clean slate" of the brain are more enduring, underlying and peering through our subsequent experiences. Even to ourselves, sensible to the hope of change, and therefore of a bettered condition of things, it is difficult and even distasteful to turn to the record of the past and make it give up its dead. It is hard for us to make a mental picture of the site of this city when Red Jacket lived hereabouts; scarcely possible, when, farther back still, in 1687, La Hontan traversed this place. But in the history of North America we can go back by the light of creditable documents to the year 986, when Biarne, the son of Bardson, set sail from Iceland, and, losing his way, came in sight of Newfoundland. Back of the earliest discovery by our race of this continent of North America must lie the history of the Indian. In Mexico traditional historic accounts take us back as far as the sixth century. And, for a still earlier time and its events, we have to penetrate the surface of this continent itself. The earth holds the further answers to these questions. In a story of ancient Greece, we read that there was a dispute as to whether Salamis had formerly belonged to the Athenians or the Megarians. When it was referred to Solon, he caused the graves to be opened. It was found then that their occupants were buried according to the custom of the Athenians, and not of the Megarians. The dead men settled that question. The testimony of the dead Athenians dispensed with the formula of an oath, and was yet accepted. No appeal was necessary after such evidence, just as no statute of limitation could bar a trial of such importance. It was a case of supplementary proceedings that commanded respect.

The earth of this continent shows us that before the Indians there has been a people whom we call Mound-builders—that is, mounds were thrown up here by men whose bones we find in them, lying among rough tools and utensils, and after the mounds we name the race, who, perhaps, were not a different people from the Indians.

But for these mounds we would not know of the men who built them. They are mentioned in no history, human or divine. What

was there before the Mound-builder? I would speak to-night of what must have been long before *his* time—of *early*, though perhaps not *earliest*, man in North America. We must know this early man by our experience of his traces. New observations of fact and the ideas they have awakened in myself are put forward, so that you may judge of the reasonableness of the conclusions. And here any boy will afford a competent illustration of the evidence. Almost the first thing that our boys do is to throw stones. It is one of their ways of saying No. There is more than one parallel between savages and our boys to be maintained. Just as the state of mind of the adult savage is paralleled by that of our children, so we must expect that so common a weapon as a stone is to our boys must be extensively used by savages. And this, in fact, is what we do find. There was also a time when this stone-throwing was the occupation of grown men of our own race. Stones were used in the warfare of the Celt and the Roman. We remember that David, a Semite, used a pebble from the brook. And we shall find that men of other races, and before David, resorted to the same weapon for all the purposes which in David's time, and with his race, were partly served by metals. There is, then, not only a parallel to be drawn between our boys and savages in certain ways, but there exists one between these boys of the present and our own men of the past. Just as, when cutting into the crust of the earth, we find the remains of animals and plants which once inhabited its former surfaces, the simpler forms below, the more complex above, so we find the remains of man's tools and implements in the clays and gravels of the last geological period of the globe, and with a like sequence in their character. The oldest and lowest forms of tools are simplest; the newer and nearer to the present surface, the more varied and complex. We have seen that the simplest weapon man could use would be a stone. Even now a wagoner with broken cart looks around naturally for a stone to pound with, and so mend his ways. He picks up a stone on occasion as his ancestors did on most occasions. For the moment he is in the Stone age. And he uses what the earliest man must have undoubtedly used, a stone just as it is. There must have been a time when men picked up such stones as came in their way at the moment with which to throw at animals, to break their food, to injure their fellow-men. Such stones, unaltered by use, can no longer be identified.

It is easy to see how, through long lapses of time, men continued to select stones, with an ever-increasing care as to their shape and size. The best to fling, the surest to hit, the sharpest to cut, were picked out, assorted in leisure moments, stored for future use. The hunter, meeting with game, could find no stone suited to bring it down at the moment, and so came at last to carry this primitive shot about with him in his hunting. The way from such a process, and a mode of improving the best of these stones by an artificial changing

of their shape and size, were clearly pointed out by experience. And there must have been a gain in the process to such an inventive tribe. No more were long searches for properly-sized stones necessary. By means of harder stones others were chipped and shaped, and so much time was gained from looking for stones and devoted to obtaining food. And tribes using artificially-shaped stones must have had a superiority over those who relied on what natural stones they found at the moment. They stood in less danger of starvation. In the absence of other remains, the presence of roughly-fashioned stones will be the earliest reliable trace we shall find of the existence of men. In Europe such stones have been found and described by several observers. In North America we owe their discovery to the zeal of Dr. C. C. Abbott, aided in funds for excavation by the Peabody Museum of Archæology, of Cambridge, Massachusetts. The rough-stone implements discovered by Dr. Abbott in New Jersey are chipped so as to form an irregular cutting edge. They are flattened on the under side and broken to an edge from the upper. The material itself is basalt, a common kind of mixed rock of compact texture. As we find them, the surface is slightly rusted, from the particles of iron in the stone. This kind of rock is common, and the tunnel of the Erie Railway at Jersey City is cut through stone of this kind. North American rough-stone implements vary little in size and pattern, although, when we examine all the kindred rough-stone implements of the world yet known, we see that, as a class, they become gradually more determinate in their shape and the chipping more regular; they come more into the shape of spear-heads, and, perhaps, large arrow-points. Above the rough-stone implements we find those of polished stone; a departure showing that man was no longer satisfied with his first rude fashioning of his implements. Then we find the metals; and of these copper, being more pliable, is first beaten cold and worked into shape for use. Then the process of smelting and mixing with harder metals, such as iron, came to be employed; and to-day we are doing just what man has always done, improving our tools so that we may better our condition.

Surveying the whole field gone over by scientific men in recent times, we must say that these different ages have merged gradually into one another. The age of rough-stone implements or paleolithic, the age of polished-stone implements, or neolithic, the ages of copper, bronze, and iron, have succeeded each other without the possibility of our drawing the dividing line, any more than we can say exactly when what we call the middle ages ceased and modern time came in.

Certain implements are, indeed, rough stone, and others polished, but between them are intermediate specimens, and both kinds seem to have been sometimes in use at the same moment with the same people. Again, the introduction of bits of copper in some of the earlier graves precedes the fashioning of copper axes. It is a similar

question to that as to species. It is not necessarily each time a different people, but sometimes the same, at first using a more simple and then a more complex implement. All mankind have not progressed equally. Some are in the Stone age now. There have been arrests in development, and a comparison of the points which the different races have reached will show the differences in standing between them. In Europe, Lyell has given a very complete account of the different kinds of implements found in one locality, the valley of the Somme. In the peat-bogs on either side of the river are found Roman weapons, belonging to the age of metals. In the gravel and clay-beds below, polished and rough stone implements are found. In North America the iron tools are wanting. The Indian was in the Stone age at the advent of Europeans. The Mound-builders had used copper, but the process of smelting and the use of iron had not been reached by them.[1]

QUATERNARY.

AGE OF MAN.

Autocene.	Holocene.	Pleistocene.	Ice-Period.
Alluvium.	Peat-beds.	Gravel-beds.	Unstratified drift.
Age of Metals.	Neolithic implements.	Paleolithic implements.	Paleolithic implements.
	Mastodon.	Horse.	Reindeer.

TERTIARY.

AGE OF MAMMALS.

Pliocene.	Miocene.	Eocene.
Horse.	Miohippus.	Orohippus.
Pliohippus.	Mesohippus.	Eohippus.
Protohippus.	Brontotherium.	Coryphodon.
		Tillotherium.
		Dinoceras.

In the accompanying diagram, while I have indicated the geological succession of the implements of man, you must bear in mind that, since stone implements are yet used in some parts of the world, they are there found in surface or alluvial deposits. But for our race the Stone age has passed, and, to find in Europe the implements our forefathers used, we must go in most cases into lower than surface-beds. And Dr. Abbott has drawn attention to the fact that there is a great similarity between the North American and European rough-stone implements. This does not indicate so much identity of

[1] The difficulty of supposing man to have been originally introduced into North America during the Quaternary lies in the fact that he was most probably in the Paleolithic age when the migration was made. This difficulty vanishes, if, as I suppose, man entered upon possession of this continent during the Pliocene, before the Ice period had interfered with a passage from the north by land. This will leave us free to consider the American civilizations indigenous.

race as identity of culture, while there is great probability that both are implied. We must remember that as we go back in time we should find the races of men less numerous than at present—the nearer we get to the common stock from which it is believed all mankind must have sprung. The survival of stone implements is not unlike the persistence of older forms of life. The gar-pike (*Lepidosteus bison*) still inhabits our lakes, but the age when the ganoid type of fishes prevailed has long gone by. In order to make the age of the North American rough-stone implements clear, we must study the geological evidence.

Clay and gravel are made, we know, from the primitive rocks. The atmosphere and the rain loosen large pieces of rock from the mountains, and they are broken in the beds of streams by the action of the water. The fine particles are produced by the rubbing of the stones together; the water grinds the broken rocks down smooth, and makes pebbles of them. Gravel, sand, and clay, produced in this manner, become sorted out by the action of the water, or *stratified*. From a study of the action of existing glaciers or ice-masses on the Alps, or in the North, it is seen that clay and gravel are also made from the primitive rock, ground out by the slow movement of the ice. The mass of dirt and stones is discharged at the edge of the glacier much as a bar is formed by a river.

But there is this difference, that the bar made by the glacier, and which we call a moraine, contains its gravel and clay and bowlders, in a confused mass, with little sorting, and thus *unstratified*. Now, these rough-stone implements have been found in New Jersey by Dr. Abbott, in unstratified beds of material, which are evidently, from their composition, ancient moraines. There are, we know, different degrees of evidence. A fact may be either demonstrated, or shown to be probable, or possible. I leave it to you to judge whether these circumstances do not demonstrate that North American rough-stone implements are as old as the beds in which they are found. To me, it seems clear that the men who used these rough tools dwelt on the edge of the glacier, and their implements have become buried in the moraines which were forming at many different points during the ice-period. Nor can we refuse to admit what this demonstrated fact implies, the great age of man in North America. I have taken, on a former occasion, the sum of 100,000 years as the time that has probably elapsed since the retiring of the glacier from the valleys of the White Mountains, in New Hampshire. This figure was arrived at after a calculation based on the ratio of movement of bodies of ice, and the round number may be considered as an under rather than over estimate. But, at whatever time during the glacial epoch the moraine was formed, in which Dr. Abbott found these implements of early man, it is quite clear that this knowledge alone will not give us the duration of man's existence in North America; for it is certain

that man could not have originated at the foot of the glacier. The ice must have met him toward the close of the Tertiary period in the northern parts of Asia and America, and forced him southward; or, at a later time, it must have found him on the main belt of this continent. The Tertiary origin of man is presupposed, from the fact that he had submitted to a race-modification fitting him to endure the cold.

Let us consider for a moment what this glacial epoch really was. As to its occurrence, the ice has left its mark on the rocks, and we see its moraines and transported bowlders over a vast portion of this continent from Virginia to the Pacific. There is no doubt that a vast ice-sheet, a continental system of glaciers, was here at a distant time. It has transported masses of rock, and left them on the summit of Mount Washington, where they still remain, and to do this it must at one time have overtopped the mountain. The ice gradually spread from the north, and its progress was slow, as we judge of time—so slow that it must have seemed immovable and unchanging from year to year, to the man of the epoch, just as it seems to us now; and just as slowly as it advanced it retired again to where it is to-day.

The glacial epoch comes in between the present or Quaternary division of time and the Tertiary. In order to estimate its effects, we must briefly consider the aspect of the earth before its advent and in the preceding epochs.

There are two principal conclusions to be drawn from an examination of the fossil remains of plants and animals during the Tertiary. The first is, that the climate over the largest portion of the globe was then equable. There were then apparently no seasons—the summer seems to have been perpetual. The proof of this lies in the fact that there was a general distribution of plants and animals over the whole surface. In Greenland and Arctic America there were forests of trees, as attested by the remains of their trunks, stumps, and leaves. The same regions reveal to us coal-fields, and the fossil remains of reptiles like those we find in beds of the now temperate zone. We find beds of coal on desolate islands in the Southern Pacific Ocean, islands so cold and barren as to afford now but weak and little plants; whereas these beds of coal attest the presence once of a luxurious vegetation, of which they are the remains.

The second conclusion is, that the Tertiary was the richest in the number and kinds of the higher animals as compared with the present or any preceding geological period in the earth's history. Then our Territories supported all the various kinds of animals, for instance, which culminated in the horse. The remains of hundreds of species of animals have been collected by Prof. Marsh from a region which now supports but very few.

Prof. Huxley has, by his now famous lectures in New York City the past year, made popularly known the discoveries of fossils by

Prof. Marsh in the Western cretaceous and tertiary beds. It remains but to add a link to the genealogy of the horse, discovered by Prof. Marsh since the time when Prof. Huxley lectured. You will remember that Prof. Huxley showed that there was a regular series of progressive forms from the Eocene *Orohippus* to the recent horse, in the character of the teeth, and in the structure of the fore and hind feet. There was more than that, perhaps, when we consider that there was an increase in size, in length of limb, and consequent activity, of the animal. In the *Orohippus* we have four toes on the front and three on the hind limbs, and so far Prof. Huxley was able to trace the genealogy of the horse with its single toe down toward the type of mammals with five toes. But we can now go a little further in the process of the evolution of the horse. In New Mexico, in a fossil bed, the horizon of which is below that in which the *Orohippus* occurs, Prof. Marsh has found the remains of an animal which he calls the *Eohippus*. The feet, which are very much like those of the *Orohippus* with their well-developed four toes in front and three behind, show a rudiment of the outer or fifth toe. The *Eohippus* was an animal as large only as a fox, though perhaps a little stouter, and, from the structure of its limbs, is the nearest yet discovered progenitor of the horse to the usual five-toed mammalian type. And in his lecture Prof. Huxley anticipated the actual discovery of the *Eohippus* by showing that such a form must have existed as the progenitor of the four-toed horse. Animals, also, which were the prototypes of the camel, have been there discovered by Prof. Cope. Strange if, at the time when the whole earth presented such a profusion of vertebrate life, man should not also have appeared upon the scene! The conditions were never so perfect, either before or since. Over this field of luxuriant life, the cold broke in. The ice commenced to form, and then to move in masses, scattering or extirpating the plants and animals. There were migration and adaptations. Such animals and plants as could adapt themselves to the cold persisted. To probably smooth-skinned elephantoid types, the woolly mammoth succeeded in the northern regions. Stunted willows replaced tree-like plants of the same botanical family. If it met man, it must equally have modified his habits of life and his physical characteristics. It must have made something like an Esquimaux of him. As to the cause of the glacial epoch itself, from a study of all that has as yet been said on the subject, we must ascribe it to upheavals of land in the north, and a change, perhaps a consequent change, in the earth's position toward the sun. There was, it seems, an elevation of the earth's crust and a variation in the earth's axis; which latter, in order to have produced the climatic effects of former geological periods, must apparently have been more nearly perpendicular than it now is. It is probable that oscillations then set in, which may make a second glacial epoch probable, although of this we cannot speak with certainty. Evidence is

already at hand, collected by European observers, that the glacial epoch itself was not continuous, but intermitted by a warmer time during which the ice retreated to reoccupy that portion of its former territory from which it has now finally retired. Prof. Dana has contributed some evidence of a similar action on North American territory. But for our present purpose a general view of the Ice period is all that we need. Evidence is at hand that the glacier, at the time it traversed our territory, was accompanied by plants and animals different from those now inhabiting the Atlantic States.

Remains of the reindeer have been discovered by Prof. Dana in clay-beds thrown together by the action of ice. This animal is now, as we know, confined to arctic regions, but then ranged the valley of the Connecticut. And there has been a sort of natural trap set for the animals and plants of that time, which caged a part of them, so that we may examine some of their live descendants.

It has been found that the condition of the tops of high mountains, such as Mount Washington in New Hampshire, and that of high northern regions, are very similar. It is calculated that a change of one degree Fahrenheit takes place in the temperature for every three hundred feet of vertical height. On a level the same change occurs for every sixty miles as we journey northward. We should have to travel, for instance, from Boston to Hudson's Bay, as Agassiz has shown, before passing over the same range of climatic changes as we do in one day in the Alps, thus causing a narrow strip of Alpine flora to correspond to a broad zone of northern vegetation. The mountains are thus compressed models of the physical conditions of the latitudes of the surface.

In the tropics we have mountains crowned with ice, whose summits reproduce the condition of the north-pole; and, as we descend their sides, we pass through belts of climate ever increasing in warmth, to the plain beneath, where we meet with the condition of the torrid zone. Now, during the glacial epoch, when the surface of our Middle States was covered with a coat of ice, the plants and animals had been swept southward of the White Mountains. They bloomed and lived in the spring-tides that softened the edge of the glacier, and enjoyed the short summer that there ensued at the source of streams fed from the melting ice. But, when the glacier retired, the summers over this region becoming longer, and the winters shorter, plants and animals followed the ice and their congenial climate northward to the valleys of New Hampshire. Out of these valleys the glacier finally departed also, but not without leaving some of its retinue behind. After the main glacier had left the valley, Mount Washington and Mount Adams still remained largely covered with ice, and a system of *local glaciers* filled the clefts and gorges of the hills. Allured by these, some of the plants and insects were retained and did not follow the bulk of their companions who were on their long march to the

north. But year after year it got warmer, and the local glaciers shortened, extending less and less into the valleys. The trapped insects could not then rejoin their mates, but instead climbed the mountain, dwelling farther and farther up as time progressed and the climate changed. At length they reached the summit of Mount Washington, where we still find some of them, and whence there is no escape. The plants formed patches in congenial spots on the sides of the mountain, driven upward by the new flora filling the valley from the southward. Now, in examining these colonists, we find among them the herb-like willow (*Salix herbacea*), its short stems hardly rising above an inch from the ground, and other species of plants which we have to go far north to meet again. There, too, the White Mountain butterfly (*Œneis semidea*) appears year by year, swaying in feeble flight over its narrow range, while its congeners are found one thousand miles to the northward in Labrador. These examples could be easily multiplied.

But this sort of mountain-trap was not large enough to hold such game as men and reindeer. These both went northward, and are not to be found alive with us; but the one left his implements, and the other its bones, to tell of their presence at that time, and in these latitudes.

When we come to the question as to the descendants of this early North American man, we cannot avoid studying for a moment the movements or migrations of man over the surface of the earth generally. I think we may divide his migrations into two main classes from their motives:

A *primitive* migration—one influenced solely by physical causes affecting his existence, and which must have been in more extended operation in early times when he was unprovided with means of his own invention against a change in his surroundings. Such migrations are operative now among certain of our Indians, who move from place to place with the game upon which they subsist and with the season.

A *culture* migration—one arising from a certain stage of intellectual advancement when the movements of man are determined by ultimate and not immediate considerations. The movements of the Indo-European races fall within this category. Besides these, there are to be distinguished *accidental* migrations, which man submitted to against his will. We know that insects and plants are so transported. Birds and ocean-currents carry seeds from land to land. Insects on a blade of grass or a fallen bough are carried down a river by the current to found colonies of their race far from their place of origin. And such circumstances give rise to races and varieties among species modifiable by the peculiarities of their new localities. The accidental migrations of man may be considered as belonging to the epoch of culture-migration, since they must more usually have oc-

curred with a race advanced in the art of navigation. A separation of communities under the pressure of storms, earthquakes, volcanic eruptions, may have naturally happened, however, in the earliest times. Neither the man of *primitive* nor of *culture* epochs is exempt from the control of the elements on all occasions. We must agree that we may account in great part, and reasonably, for the variation of man by the difference in his present physical surroundings.

The essential unity of origin of all the races of mankind is believed by the great majority of scientific men.

The study of the migration of mankind shows us that there has been replacement everywhere; that people now inhabiting any known country have not always inhabited the same tract of land. At the same time suppose our race to vanish entirely from this continent, leaving only ruined cities and implements behind, how difficult would it be to get a true history of our migration hither! Suppose again we had no certain account of how our forefathers crossed the Atlantic, how diverse would be our traditions! Europeans have no authentic account of how they came to be in Europe. A great deal of our American dogmatism and Philistinism is to be ascribed to the fact that we know our origin. We came from England or Germany, and that answers such questions sufficiently. It is as far as we usually think. But now we see that we cannot speak of autocthones, or people sprung from the soil they now cultivate. Such a boast has been made by more than one race, indeed by people of such different culture as the ancient Athenians and the modern Esquimaux. So that we may not conclude too rashly that the people who have left only traces in any country are extinct, because they have been replaced by a different population, just as we have replaced in the eastern portion of North America the Indians. Their descendants may exist elsewhere. This seems to be the case in the present instance, and just as the same kinds of reindeer, butterflies, and plants, of the time when the ice covered these States, no longer live here, but in a far north, so the man of the glacial epoch of the present United States has in all probability wandered after the ice —a primitive and unconscious migration determined by the shifting of his congenial physical surroundings. And the Esquimaux, as of old skirting the glaciers, the only inhabitants of the shores of Arctic America, and extending in scattered companies for nearly five hundred miles on the coast of Asia beyond Behring's Straits, may well be the modern representatives in a direct line of descent of early man in North America. They were found inhabiting this territory by Europeans first in 1616; and since that time they have been found as far north as we have been able to penetrate. The limit of their range to the southward seems to be about the fiftieth degree of north latitude on the eastern, the sixtieth on the western side of America and the shores of Hudson's Bay.

Our knowledge of the Esquimaux is far from complete. They call themselves *Innuit*, not *Esquimaux*, and the name signifies *the people*. Although divided into tribes and smaller companies, they are very uniform in their physical appearance and customs. A tribe met with by Sir John Ross about 77° north latitude believed themselves to be not only the only Esquimaux, but the only *people* in the world. As their numbers are comparatively small, and they have a total range of about 5,000 miles of coast-line, it is evident how a tribe might exist for centuries without meeting any competitors for seal and bear meat in its range. The different tribes practise a sort of communism with regard to their possessions. Different families dwell together in one house, and rely upon each other for mutual support. So much, in brief, we may say here of this people. With regard to their affinities, they are from their speech a branch of the Turanian family, and allied to the Hungarian, Turkish, Lapp, and Basque races. As to their habits, while their morals seem to be good, they are most voracious eaters, from the fact that they cannot always depend on their supply of food, and so gorge themselves when they get a quantity. Parry tells of an Esquimaux boy who ate eight and a half pounds of seal-meat, one and a half pound of bread, one and a half pint of soup, and drank three wineglasses of gin, a tumbler of hot whiskey-and-water, and five pints of water, consuming the whole, between intervals of rest, in one day. They seldom wash except in summer, in which I think they are excusable to some degree, in the absence of proper heating apparatus in their huts.

As usual, travelers and scientists speak badly of boys. It is always the *boys* who are doing the worst actions, be they Esquimaux or New-Englanders. While I myself, in the present lecture, am guilty of this unavoidable presentation of the facts, I yet believe that the most of the wrongs of this world are committed by grown-up persons, and I look to the growing generation of boys to make better and wiser men than their fathers. They have the benefit of a greater amount of experimental information stored up for them in books from which they can take fresh departures in knowledge and happiness.

It has been my aim in the present lecture to give you the result of latest information on the earlier man of North America, and at the same time to indicate some of the different branches of science which it is necessary for us to pursue in order to understand anthropology or the study of man. We have called upon geology to describe the strata in which we find the relics of man, and to explain their probable age and the manner of their deposition. Archæology has shown the progress from the simple to the complex in the various implements used by man, and has classified them. Ethnology has allowed us to discriminate between the different races of mankind, to study their habits and migrations, and classify their religions. Biology has enabled us

to study the different stages through which man as an individual passes from infancy to maturity. Psychology, finally, has taken cognizance of the various facts supplied by the other sciences, and has led us to understand how, man being known, and his environment being comprehended, we are to interpret their interaction.

There are two conclusions which I think we are warranted in drawing from the facts here presented. The first refers to the actual relation between time and development. Just as geology teaches us that the simpler organisms have existed on the earth through vastly longer periods than the more complex, so it shows us that the ages during which man used simpler and stone implements were greater in duration than those in which he has used more complex and metal tools. Let us compare what we are doing now with metals, and what we did with them during the miserable epoch we call the "age of chivalry," of which sentimentalism still gives us false and fanciful pictures. The second conclusion springs from the first. As the true history of our own race shows that we came from a low and brutal state, common once to all mankind, so the facts of our present condition give us reasonable hope for a better future. Let us, then, stand on the highest points of knowledge in all its departments, for these are touched with light. We must reach these heights by continual reading, observation, and experiment. The result of these is culture. All thought has an added beauty as it approaches the truth, but what is needed is to attain to clear conceptions. Our impressions are blurred because we do not see facts clearly in all their relations, and such impressions are ugly because they are imperfect. We are yet in the morning of culture. We are only becoming sweet, as wild-apple trees grafted on single boughs. It is not so much that we are sinners as that we are sluggish and stupid that is the matter with us. It is certain that there is a better time yet to come for our race upon this earth than the present. It will be reached by a continuous exercise of our brain-power, giving us right reason at last, the permanent correction for faults of conduct and for errors in our ideas. Sir Henry Maine has said that "conceit and skepticism are the products of an arrested development of knowledge."

BIOGRAPHICAL SKETCH OF THOMAS EDWARD.

MANY of our readers, as their attention is arrested by the portrait we furnish this month, will glance at the name beneath it, and musingly ask themselves whether they have ever seen or heard it before. They will say, perhaps: "There were several Edwards, who were Kings of England, and there was Edwards, who made a book upon the will; and there is Milne-Edwards, the great naturalist of

the French Academy; but—Thomas Edward—Tom Edward—who is he? and what business has his portrait in THE POPULAR SCIENCE MONTHLY, where we expect to find likenesses of only eminent scientific men?"

Well, the Thomas Edward whom we represent is in his proper place; and, if he has not been heard of before, he ought to have been. He was certainly not a King of England, but he has been a king and a hero in his own way; and we are glad to note that the Queen of England and Empress of India has recently honored herself by hon oring him. Nor has Thomas Edward, like the great Jonathan, ever written on the will; but he is one of Nature's illustrations of it, and is himself a living treatise on the force of the will. And, although he is not a rich Anglo-French naturalist, the pet of the Academy, and applauded through Europe, he is nevertheless an eminent naturalist, who in an obscure Scotch town, without education, without means, without books, without encouragement, and without the acquaintance of men of science—a poor, day-laboring mechanic, with a large family—has done original work in science, of a quality and extent that would have carried half a dozen common men into the American Academy of Sciences, or the Royal Society of England. Thomas Edward fought his way alone, inspired and sustained by a love of Nature which with him was nothing less than an ungovernable passion; and, although working in long obscurity and bitter privation, and under difficulties that would have crushed the spirit of ordinary men, he has at length met the reward he so richly deserves, by falling into the hands of a gifted and admiring biographer. Well can he have waited, and much can he have suffered, who secures the genius of Mr. Smiles to write his life while he is yet living, the skillful pencil of Reid to illustrate it, the aristocratic house of Murray to publish it in his native country, and the enterprise of the Harpers to reprint it in the United States. We make free use of Mr. Smiles's work [1] in the following pages.

THOMAS EDWARD was the son of a hand-loom weaver, and was born near Aberdeen, in Scotland, in 1814. From his birth he was difficult to manage. His mother said of him that he was the worst child she had ever nursed. He was never a moment at rest, his feet and legs seemed to be set on springs. In babyhood he showed an impulse to leap from his mother's arms after flies. As soon as he began to walk he made friends with the cats and dogs, and would toddle out into the streets to cultivate the acquaintance of the hens, ducks, and geese, and would watch the pigs in a pen for hours. As he grew older he became a desperate rambler and runaway, and developed a

[1] "Life of a Scotch Naturalist: Thomas Edward, Associate of the Linnæan Society." By Samuel Smiles, author of "Lives of the Engineers," "Self-Help," "Character," "Thrift," etc. Portrait and Illustrations by George Reid, A. R. S. A. Harper & Brothers.

passion for collecting all sorts of natural objects, crabs, worms, beetles, rats, tadpoles, frogs, snails, leeches, mice, birds, and birds'-nests, which he would bring home, and which were the nuisance and pest of the house. His mother protested and forbade, and threw his "venomous beasts" away, but it was of no use. He was threatened with punishment, and the same night brought in a nest of young rats, when, of course, he was flogged. But blows did no more good than words. When sent to carry his father's breakfast, he cut for the seashore. One morning his mother tied him up firmly to a table to prevent his going out, and set his little sister to watch him. As soon as his mother was absent, with a mixture of promises and threats he made his sister help him, when they pushed the table so close to the grate that he was able to burn off the rope and get away. Tom got at liberty and had a good time that day in the fields. One morning his father hid his clothes, so that when the boy got up he had "nothing to wear." His mother tied a bit of old petticoat around his neck, saying, "I'm sure you'll be a prisoner this day." He tied a string around his middle, hid himself awhile in the entry, and at an opportune moment bolted into the street, and was soon at the shore hunting for crabs, horse-leeches, puddocks, and sticklebacks. But the exposure was too much for him, and he had a long fever, with delirium, hanging between death and life for several weeks. When he recovered, the first thing was to inquire after his beasts. When but four years old he was thrashed and starved and shut up to keep him at home, but he was self-willed, determined, stubborn, and thoroughly incorrigible. He wandered about the beach, rambled over the country, learning all the best nesting-places of the birds—in the woods, plantations, hedges, streams, and mill-dams. He was inquisitive and thoughtful, often asking for information, but rarely getting it. He knew how birds made their nests, and how the flowers grew out of the ground, but he did not know how the rocks grew. He asked his parents, and they told him the rocks had existed from the beginning. This did not satisfy him, so he went to the quarrymen. "How do the rocks grow?" asked he. "Fat say ye?" Tom repeated the question. "To the deil wi' ye, ye impudent brat, or I'll toss ye owre the head o' the quarry!" Once he saw a paper-like something up in a tree, with lots of yellowish bees about it. This started his curiosity, and he tried to get the other boys to join him in securing it. They refused and ran home, leaving him alone. He climbed up near the limb where it was suspended, and was met by a sting which he thought was more painful than any he had ever had before. He sucked and blew the wound, but there hung the wasp's nest, and he could not leave it. It was growing dark, he could not put it in his bonnet nor in his stockings, so he stripped off his shirt, and, though getting numerous stings, wrapped it around the nest, detached it, and carried it home. His father, seeing him shirtless, threatened him with

the strap, sent him to bed, and the shirt, with its contents, was soon put in a bowl, and covered with boiling water.

The time at length came when Tom Edward must be educated. To be sure, he had been educating himself pretty rapidly, but he must be sent to school. This he hated. He could not bear the confinement. When between four and five years old he was sent to a dame's school, kept by an old woman called Bell Hill in the garret of an ordinary dwelling-house. But he often played the truant, and would rather be in the fish-market than the school-room. His truancy soon became known to his mother, who then employed her mother, Tom's granny, to take him to school. But Tom rebelled against his granny's supervision, and got away from her so often that she had to drag him "by the scruff o' the neck." Once he slipped away from her, and ran for the water, and was in the act of getting a lot of horse-leeches, when his granny, who had pursued him, caught him by the neck. He let go of the stone, and, making a sudden bound, upset the old woman in the water. His comrades called out, "Tam, Tam, your granny's droonin'!" Tom was off, and did not get home till night, when his mother abused him for a ragamuffin who tried to drown his granny. For once his father was in good-humor, and remarked to his wife that "granny should beware of going so near the edge of such a dirty place." The scapegrace returned to school, but did not learn much. The education that Bell Hill gave was rather theological; she prayed, or, as Tom called it, "groaned," with the children twice a day, and in one of these devotional exercises Tom came to grief. She forbade him to bring his "nasty and dangerous things" to the school, but it made no difference. He had a noisy jackdaw at home, of which he was very fond, and one day he stuffed it inside of his trousers, and took it to school. While Mother Bell was at prayer the daw became restless, got its head out, and began to scream. "The Lord preserv's a'! Fat's this noo?" cried Bell, starting to her feet. "It's Tam Edward again!" shouted the scholars, "wi' a craw stickin' oot o' his breeks!" Bell went up to him, pulled him up by his collar, dragged him to the door, thrust him out, and locked the door after him, and Edward never saw Bell Hill's school again.

Tom was next sent to a school governed by a master who had great faith in what is called the "taws"[1] as a means of education. But the boy's old habits followed him, and one day he smuggled into the school a broken bottle, containing horse-leeches and the grubs of water-flies. Mr. Smiles relates that "all passed on smoothly for about half an hour, when one of the scholars gave a loud scream, and started from his seat. The master's attention was instantly attracted, and he came down from the desk, taws in hand. "What's this?" he cried. "It's a horse-leech crawlin' up my leg!" "A horse-leech?" "Yes, sir; and see," pointing to the corner in which Tom kept his

[1] "Taws," a leather strap, about three feet long, cut into tails at the end.

treasure, "there's a bottle fu' o' them!" "Give me the bottle," said the master; and, looking at the culprit, he said, "You come this way, Master Edward!" Edward followed him quaking. On reaching the desk he stopped, and, holding out the bottle, said, "That's yours, is it not?" "Yes." "Take it, then—that is the way out," pointing to the door; "go as fast as you can, and never come back; and take that, too!" bringing the taws down heavily upon his back. Tom thought that his back was broken, and that he should never get his breath again. Tom's mother took him back to the school-room door, but before she could open her mouth the master abruptly began: "Don't bring that boy here! I'll not take him back—not though you were to give me twenty pounds! Neither I nor my scholars have had a day's peace since he came here."

Tom was now sent to a third school, where he staid eighteen months, but did not learn very much. The Bible was the reading-book, and he got so that he could read it, and also repeat the Shorter Catechism. But he knew very little of arithmetic and nothing of grammar. He could add up two lines of figures, but could not manage the multiplication-table. He could only multiply by means of his fingers, and knew nothing of writing. He had given up bringing beasts with him to school, but he had got a bad name. One morning, when the boys were at their lessons, the master gave a loud scream, and, jumping to his feet, shook a big worm from his arm; then, turning in Tom's direction, he exclaimed, "This is some more of your work, Master Edward." Edward was then called to the floor. "You've been at your old trade, Edward, I see; but I'll now take it out of you. I have warned you not to bring any of your infernal beasts here, and now I have just found one creeping up my arm and biting me. Hold up!" Edward here ventured to say that he had not brought the beast, and he had not brought anything for a long while past. "What! a lie, too?" said the master. "A lie added to the crime makes it doubly criminal. Hold up, sir!" Tom held up his hand, and the master came down upon it very heavily with the taws. "The other!" The other hand was then held up, and when Tom had got his two hot hands the master exclaimed, "That's for the lie, and this for the offense!" and then he proceeded to bring the taws heavily down upon his back. The boy, however, did not cry.

"Now, sir," said the master, when almost out of breath, "will you say now that you did not bring it?" "I did not; indeed, sir, I did not!" "Well, then, take that," giving him a number of tremendous lashes along his back. "Well, now?" "I did not!" The master went on again: "It's your own fault," he said, "for not confessing your crime." "But I did not bring it," replied Edward. "I'll flog you until you confess." And then he repeated his lashes upon his hands, his shoulders, and his back. Edward was a mere mite of a boy, so that the taws reached down to his legs, and smote him there.

"Well, now," said the master, after he was reduced to his last effort, "did you bring it?" "No, sir, I did not!" The master sat down exhausted. "Well," said he, "you are certainly a most provoking and incorrigible devil." He ordered Tom to get his slate and books and quit the school. And with this third expulsion Thomas Edward finished his "education" at the age of about seven years.

And let us not be hard on the Scotch system of education. To be sure, the schools did but little to encourage a taste for natural history, but we have a great many pretentious educational establishments now that are not a whit in advance of them. And our state system has no place for little enthusiastic nuisances like Tom Edward. A teacher in a Brooklyn institution of high claims, thinking, not long ago, that the book "natural history" might be somewhat alleviated by a little acquaintance with the real objects about which the pupils were learning lessons, encouraged them to collect some natural-history specimens. A few cocoons were accordingly brought in, and hung up in the class-room, and watched with much eagerness until the pupils began to fear nothing would ever come of them. But one morning it was observed that a large and beautiful moth was emerging from a chrysalis, and the class became much excited with interest at the novel and curious spectacle. But for such excitement, from so strange a cause, there was no provision in the order of the school. And when the grammarian came in to take the class, they did not enter into his stupefying processes with the customary facility, at which he was so shocked that he reported his difficulty to the governing authority, and a score of the children were kept after school as a punishment for the interest they had taken in an insect metamorphosis!

School being done, young Edward went to work. He first got a place in a tobacco-factory at fourteen pence a week. Here he staid two years, having risen through the grades of responsibility until he got eighteen pence a week, but his master happened to be a bird-fancier, and favored Tom's tastes in catching animals. Leaving this place, he got a situation in a woolen-factory, at some distance from home, receiving at first three and at last six shillings a week. Besides, he got on as a night-hand, and thus had much of the day to himself for rambling in the woods, and getting acquainted with the flowers, insects, and birds. These were happy times. Tom was at the factory two years, and was then taken away that he might be bound as an apprentice to a trade. The happy genius of his father selected for him as a life-occupation the intellectual and ennobling craft of the shoemaker. He was indentured at the age of eleven to Charles Begg, who was to teach him for six years the art and mystery of making shoes, at eighteen pence a week for the first year, with sixpence a week advance each succeeding year—aprons and shoes to be supplied—time, six in the morning until nine at night; specialty, pump-making, in which Begg excelled.

Charles Begg was a low-class London cockney, and an ignorant, brutal vagabond, who had a habit of coming home drunk, of thrashing his apprentice, and then going up-stairs and beating his wife. His relation to natural history was the same as that of Tom's teachers. He had no love whatever for the works of Nature, and very naturally detested those who had. Tom had a love of birds and living creatures, and Begg hated him accordingly. If Tom brought any curiosities, Begg threw them into the street—his little boxes, with butterflies, birds'-eggs, etc. One afternoon, when Edward had finished his work, he was sitting with a young sparrow on his knee which he had trained and taught to do a number of little tricks. It was his pet, and he loved it dearly. While thus occupied the master came in drunk, and, seeing what he was doing, knocked him down, while the bird fluttered to the ground, was trampled on, and died. In this way three years passed, when one day Edward brought three young moles to the shop, in his bonnet. When Begg found them, he killed them at once, knocked down Edward with a last, seized him by the neck and breast, dragged him to the door, and with a horrible imprecation threw him into the street. Tom did not return. He wanted to be a sailor, but his father opposed it. He then ran away from home to see an uncle a long way off, who kept him all night, gave him eighteen pence, and sent him back. He had various adventures in this excursion, such as the following: He came up to three men standing in the road; two of them were gentlemen, and the third seemed to be a gamekeeper. He was showing them something which he had shot in the adjoining wood. Edward went forward, and saw that it was a bird with blue wings, and a large, variegated head. "What do you want?" said the gamekeeper to Edward. "To have a sight of the bird, if you please." "There, then!" said the gamekeeper, and thrust the bird in his face, nearly blinding him. When he got home, he tried the ships again, to go to sea, and attempted to get on board of a vessel as a "stow-away" to go to America, but could not accomplish it. So he resumed shoemaking with another and kinder employer, who did not persecute him for his love of natural things. He now started a little garden for wild-flowers, and began to prepare places for his various creatures, but his resources were too rude, and his knowledge not sufficient to succeed very well. He made tours among the booksellers to inspect the pictures in the windows, and now and then was able to buy a cheap book. He took the *Penny Magazine* and the *Weekly Visitor*, which cost but a half-penny. He was now about eighteen years old, and, the shoe-business growing flat, he enlisted in the militia for a short time, and one day, when on drill, a large, brown butterfly flitted past, such as he had never seen before, and in an instant he was off after it. After chasing it awhile, he (not the butterfly) was captured by the corporal and four militiamen, who marched him to the guard-house. The high functionaries were astounded, and pro-

nounced that he must be either mad or drunk. At the intercession of some ladies, the punishment of his heinous offense against the military majesty of his country was remitted.

When about twenty years of age Edward left Aberdeen, and went to Banff (a pleasant country town about fifty miles away, standing upon a gentle slope inclining to the sea), to work at his trade. Wages were low, and he was confined many hours in the shop, but he continued to make his natural-history collections. When twenty-three years old he married, and was fortunate in finding a woman of common-sense, who sympathized with his peculiar tastes. She had nothing, and they began to keep house on his earnings, which were 9*s.* 6*d.* per week. But he now, for the first time, had a place and room for his specimens. His education had been very limited, he could hardly write, he knew next to nothing of books, did not possess a single work on natural history, or know the names of the birds and animals that he caught. He also knew little of the nature and habits of the creatures he went to seek, or where or how to find them But he had this great advantage, that he was compelled to observe for himself, to think for himself, so that the knowledge he acquired was his own. He was modest, self-depreciating, and shy, and as his fellow-mechanics were an ignorant and brutal lot, with whom he associated very little, he was alone and friendless, which again favored the absorption of his mind in natural objects. He got compensation, for he was an intense lover of Nature, and to be in the fields, the woods, the moors, was always a great delight. When he had been married about a year, he began to make a collection of natural objects. He bought an old gun for 4*s.* 6*d.*, but it was so rickety that he had to tie the barrel to the stock with twine. This, with his powder-horn and shot-bag, a few insect-bottles, some boxes for moths and butterflies, and a book for putting plants in, constituted his equipment. He had a two-story hat, the upper chamber of which was a useful receptacle, while the crown served for sticking in and carrying his entomological pins. He carried no cloak or umbrella, and his food was a bit of bread, or a little oatmeal, which he washed down with water from the nearest spring. He never rambled on Sunday, but made it a day of rest, which was fortunate, as, without this break, he could hardly have continued his overstrained and exhausting life.

Mr. Edward had to support his family by piece-work, which occupied him from six in the morning to nine at night, and his wages were so small that he could not abridge his working-hours. But he was a man of invincible determination, and he resolved never to spend a moment idly, or a penny uselessly. Closely occupied during the day, the night was all that remained for "leisure," and that he divided between sleep and night-wanderings after animals. On returning home from his work at night, his usual course was to equip himself with his tools, and start for some one of his locations for observing. It mat-

tered little about the weather. His neighbors used to say, "It is a stormy night that keeps that man Edward in the house." He went out in fine, starlit nights, in moonlight nights, and in cold, drizzling nights. When it rained, he would look out for some hole in which he could get partial protection, and then watch for night-moving animals, insects, and birds: foxes, badgers, rats, weasels, polecats, mice, bats, owls, moths, and a host of other creatures of nocturnal habits, were the objects which he sought to observe in their ways or to obtain for his collections. It is comparatively easy to observe the habits of animals by day, but very difficult in the obscurity and darkness of night. Edward's circumstances drove him to this night-work, and soon made him expert in this peculiar line of observation. He often went out in winter, but his principal night-work was by moonlight, from spring to autumn. Seeing was of course difficult, but was greatly helped by the sounds of the midnight prowlers. In the course of a few years he learned to know all the beasts and birds of the district frequented by him. He knew the former by their barkings, gruntings, and various cries, and the latter he could identify even by the sounds of their wings when flying. He could tell the species and families of birds by their call-notes as they flew by. He would watch the fights, greetings, pranks, predacious assaults, and peculiar ways, of the midnight roamers, between snatches of sleep, and thus extended and made much more accurate one of the obscurest branches of natural history. Mr. Edward had numerous adventures in these nocturnal excursions, which are vividly related by Mr. Smiles, who also goes into much detail to illustrate the perils, exposures, and privations, of this mode of life.

Mr. Edward continued his night-researches for about fifteen years, his excursions extending for six or eight miles in different directions. He found many new specimens, and was particularly persistent in working at the birds which greatly abound in that region. He thus rapidly accumulated the objects for a collection, and after eight years had preserved nearly 2,000 specimens of living creatures found in the neighborhood of Banff, most of which consisted of quadrupeds, birds, reptiles, fishes, crustacea, star-fish, zoöphytes, corals, sponges, and other objects, together with an immense number of plants. He placed these in cases, which he made himself by the aid of a shoemaker's knife, a saw, and a hammer. He stuffed his own birds, and mounted all his own objects. Of course, he was not exempt from the accidents to which such material is exposed. He had deposited twenty boxes, containing 916 insects, in his garret, and when he went to fetch them he found they had been all eaten by the mice, the pins only remaining, with here and there a head, leg, or wing. On another occasion, having put 2,000 preserved plants in a box which was carefully placed out of harm's way, when he went to overhaul them he found that the cats had made their lair in the box and ruined the whole collection.

There was an annual fair at Banff, and in 1845 Edward resolved to exhibit his collection. So he brushed up his specimens, cleaned his cases, of which he had about 300, and exhibited them, or rather had them placed on exhibition, at Trades Hall. He made a small charge for admission, and received quite a number of visitors. It took the inhabitants by surprise, and they began to understand him; his strange night-wanderings having been a matter of much wonderment and mystification to the people of the town. He got a little money and without much expense by showing his collection, and, being very anxious to turn himself in some way so as to get relief from the drudgery of the shop, and acquire time and means for more devotion to his favorite pursuits, he formed the perilous resolution of trying Aberdeen as a place of exhibition. This city was the old centre of northern intellect, cultivation, wealth, and business, with two universities, filled with professors and students, and a large, intelligent, and thrifty population. Edward got his collection into six carrier's carts—there being no railroads—and started out with his wife and five children July 31, 1846, reaching Aberdeen on the evening of the following day. He took a shop, advertised, and scattered handbills. Terms of admission, "Ladies and gentlemen, 6*d.*; tradespeople, 3*d.*; children, half price." The *Aberdeen Journal* thus noticed the collection: "We have been particularly struck with the very natural attitudes in which the birds and beasts of prey are placed; some being represented as tearing their victims, others feeding their young, and some looking sideward or backward, with an expression of the eye which indicates the fear of interruption. The birds are very beautiful, and the entomological specimens will be found exceedingly interesting." Edward expected a rush, but he was disappointed. But very few persons called to see the collection, and these were chiefly stuffed-bird dealers, who wanted to sell him specimens, or knaves with counterfeit monstrosities to dispose of. Some ladies called, to consult him about sick lap-dogs, diseased cats, and a broken-legged pig. One gentleman wished him to come and cut off the front teeth of an old and favorite rabbit, as they had grown so long that he could not eat; but only very few came to see the collection, and of those who did come none could be made to believe that the specimens were all collected and prepared by a man who had to work all day to support his family. Professors of the university came and told him that the inhabitants of Aberdeen were not yet prepared for an exhibition of this kind, though the reader will observe that the incorporated town was seven hundred years old and contained sixty churches, while its university had been operating on the Aberdonian mind for two centuries and a half! The fact is that, notwithstanding all its "culture," Aberdeen was no more appreciative of a true lover of Nature than Tom Edward's teachers had been; and he went out of Aberdeen in much the same way that Begg pitched him out of his shop. He got in debt, became discouraged and

half distracted at his situation. More advertising only aggravated his trouble. After a month he had lost hope, and, what was worse, his master at Banff wrote him that if he did not immediately return he would lose his place. He became despairing, and started for the seashore with a view of putting an end to his troubles. He had thrown off his hat, coat, and waistcoat, before plunging into the sea, when a flock of sanderlings lit upon the sands near him, and among them a larger and darker bird, that he was not acquainted with. They flew, and he followed them, again and again, until he exhausted himself, and worked off his misery. Nothing remained but to sell his collection, which he did for twenty pounds to a gentleman who wanted it for his boy. These specimens were stored in a damp room, and eventually perished; but the exhibitor got out of debt, and went back with his family to Banff.

Edward felt crushed and ruined when he got back to his home. He had not only lost the precious fruits of many years of loving labor, but his hopes of anything for the future but slavery in the shop were blighted, and his life looked dark and desolate. He resumed work, but at first had little spirit to begin replacing his lost specimens. Yet, as spring advanced, his passion again took possession of him, and he girded himself with his gun and insect-boxes and various appendages, and again sought his old haunts of observation. His zeal and perseverance were now greater than before. His friends protested that his exposures were wearing him out, but he says: "One look at my cobbler's stool dispelled every consideration. My wish was, at some time or other, to wrench myself free from my trade." He now improved his outfit by getting a coat with eight large pockets, and had four ample receptacles in his waistcoat; besides, he had a number of bags and wallets geared for convenient carrying, and all were stocked with facilities for advancing his work. On one occasion, after a prolonged tour, and when all his boxes and cases were filled with insects and worms of every sort, he was caught in a terrific thunder-storm, and soaked through and through by the rain. He reached a house at length and sought shelter, but the glue of his boxes had softened by the water, and, coming apart, let out the ants, worms, slugs, spiders, and caterpillars, so that he was completely covered with miscellaneous vermin. The woman of the house yelled at him: "Man, fat the sorra brocht ye in here, an' you in siccan a mess? Gang oot o' my hoose, I tell ye, this verra minit! Gang oot!" On looking at his clothes he found that he was a moving mass of insect-life and creeping things, and he cleared the room at a bound and took refuge in an old shed.

After his exhibition at Banff, he became a sort of general referee in regard to all curious objects found in the district, and got a great deal of advice as to what he ought to do, but nobody offered to help him. He had a family of eight, and his wages, even with extra work,

were but fifteen or sixteen shillings per week. His wife helped him efficiently; she bound shoes, and received separate pay for it, but she would often with her own earnings buy bottles for his insects, wood for his bird-cases, powder and shot for his gun. None of his advising friends ever helped him in this way.

His expeditions were often accompanied by dangerous adventures. On one occasion, as he was coming home in the morning, he shot a martin, which fell upon the edge of a cliff. He clambered to the spot, and, just as he was seizing it, it fluttered over, and in trying to grasp it he went over himself. His gun fell out of his hand, and lodged across two rocks. Edward came down upon the gun, smashing it to pieces, but it broke the force of the blow, and probably saved his life. He had descended forty feet, and was wedged in between two rocks, where he remained senseless until with great difficulty he was extricated by two ploughmen and a fisherman, terribly sore and bruised. He got home, but was unable to work, and had to sell more of his collections to meet family expenses.

Shortly after his return from Aberdeen, Edward made the acquaintance of the Rev. James Smith, who lived about eight miles from Banff, and who lent him some books that helped him to ascertain the names of birds, and Mr. Smith also urged him to publish the results of his observations. Edward replied, "I cannot write correctly enough for the publishers." "But you *must* write," said Smith. "You must note down your observations." Edward objected much, but he nevertheless took to the work, and soon developed unusual descriptive power. He wrote articles, from time to time, for the *Banffshire Journal*, on various interesting objects, which had the effect of directing general attention to natural-history subjects. Further encouraged by his friend Smith, he began to write for the *Zoölogist*, giving an account of his discoveries, and of those habits and peculiarities of animals which he had closely observed. At the end of 1855 we find an article of his in the *Zoölogist*, entitled "Moth-hunting, or an Evening in the Wood," and in the following year he commenced in the same periodical a "List of the Birds of Banffshire, accompanied with Anecdotes." This list comprised eight articles, which were received with much favor, yet he never got a farthing for any of his literary contributions!

It is worth while to note how he could write. He printed in the *Banffshire Journal* an account of a very dangerous adventure he had by getting trapped in the recess of a cliff from which there seemed to be no possibility of escape in any direction. He says: "I sat down to consider what was next to be done. While thus resting, I observed a falcon (*Falco peregrinus*) sailing slowly and steadily along, bearing something large in his talons. On he came, seemingly unconscious of my presence, and alighted on a ledge only a few yards from where I sat. I now saw that the object he carried was a par-

tridge. Having fairly settled down with his quarry on the rock, I could not help wondering at and admiring the collected ease and cool composure with which he held his struggling captive (for it was still alive) until death put an end to its sufferings. There was no lacerating with its beak at the body of the poor and unfortunate prisoner, in order, as it were, to hasten its termination; no expanding of the wing to maintain his equilibrium, although the last and dying struggle of the bird caused him to quiver a little. All being over now, with one foot resting upon his game and the other on the rock, silent and motionless as a statue, the noble captor stood, with an inquiring eye, gazing at the now lifeless form of his reeking prey, seeming to doubt the fact that it was already dead. But there was no mistake. The blood, oozing from its mouth and wounds, its body doubtless pierced by the talons of the conqueror, already began to trickle down the sides of the dark cliffs, dyeing the rocks in its course. Satisfied at last that life was fairly extinct, an incision was then made in the neck or shoulder of the victim, and into this the falcon thrust his bill several times, and each time that it was withdrawn it was covered with blood. This being done, and having wrenched off the head, which he dropped, he then began not only to pluck but to skin his food from the neck downward; and, having bared the breast, commenced a hearty meal by separating the flesh from the sternum into portions, with as much apparent ease as if he had been operating with the sharpest surgical instrument. I should have liked well to have seen the end of the work thus begun; but, unfortunately, a slight movement on my part was detected by the quick eye of the falcon, and my nearness was discovered. Having gazed at me for a few, and only for a few, seconds, with an angry and piercing scowl, mingled with surprise, he then rose, uttering a scream so wild and so loud as to waken the echoes of the surrounding rocks; while he himself with the remains of his feast, which he bore along with him, rounded a point of the cliff and disappeared; and there is no doubt that he ended his repast in unmolested security."

In 1854 Edward lost his valued friend Smith, by death, and he mourned for him very deeply, as he was a man of wide culture, and with a thorough appreciation of the character of Edward. Mr. Edward was under the impression that people looked down upon him and his work, because he was a poor shoemaker, and in this, of course, he was right. But the clergyman treated him as one intelligent man treats another. His loss, however, was greatly repaired by the acquaintance of the Rev. Mr. Boyd, of Crimond, a few miles off, also a naturalist, who had a high and appreciative regard for him. The two clergymen had made various efforts to secure for Edward some position in which he could live and give freer play to the bent of his genius. But they failed. Mr. Boyd once proposed that Edward should get up a series of rudimentary lectures on natu-

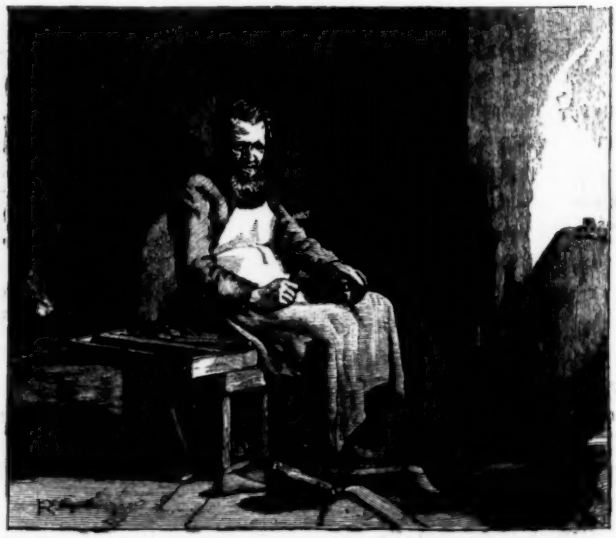
ral history, illustrated by specimens of birds and other objects. They were to be given first in Banff, and then in other places. Edward got his illustrations ready, and the project looked feasible. There existed in the town of Banff an institution which had been formed, among other purposes, "*for the discovery and encouragement of native genius and talent.*" What could be more promising? Mr. Boyd believed that they would heartily coöperate in the lectures, because it would be in accordance with the avowed purpose of the institution. Several members were applied to, to give their assistance, but they politely declined, and the scheme fell through. Shortly afterward Mr. Boyd died, and Edward was deprived of another efficient friend. "Another of my best friends is gone," exclaimed he. "Cruel Death! if thy hand continues to strip me thus, thou wilt soon, very soon, leave me desolate; and then who will take notice of the poor naturalist?"

At last, his health gave way altogether, and he had a long attack of rheumatic fever; and again his collections had to be sold, to protect the family from want. He now lost all hope of ever being able to replenish them. He had to abandon his night-wanderings, but he turned to the natural history of the sea-shore. Here he had a new field, and worked with great success. He discovered many new species of marine creatures, and greatly extended the knowledge of the habits and history of those already known. His daughters gave him very valuable assistance in many ways, especially in searching the fish-markets along the shore. Mr. Edward was, moreover, now beginning to be better known to naturalists, who sought his correspondence and his aid, and among these were Spence Bate, Westwood, Couch, and Gwin Jeffreys. Bate tried to get a place for him in a scientific institution, at thirty shillings per week, but it turned out to be a fourth portership at one pound per week, and could not be got even at that. Edward's hopes were once more blighted, and nothing remained for him but the cobbler's stool. He tried photography as a means of living, but was not able to provide a glass-window department, and failed in that also. The fact is, he was simply a born naturalist, made for the discovery of the things of Nature, and, if his Christian country had been half civilized, he would have been kept at that priceless work for which so few men are gifted by rare original endowments.

We can hardly refer to, much less enumerate, the achievements of Edward in many departments of observation, which are described with great felicity by Mr. Smiles. At the close of his volume he gives selections from the mammals, birds, fishes, and crustacea, with which this man enriched the fauna of Banffshire; but while the list comprises many hundred, in a long appendix, the author states that, if all were given, they would fill a volume. Among the crustaceans alone, of two hundred and ninety-four, found in the Moray Firth, not fewer than twenty-six new species were added by Edward himself.

But Edward's scientific labors drew toward a close. He had fought the fight of science on the one hand, and of poverty on the other, until his constitution, strained by exposure and battered by accidents, was no longer equal to the double struggle. In 1866 he was elected an associate to the Linnæan Society, one of the highest honors that science could confer upon him, and he was shortly after also made a member of the Societies of Natural History at both Aberdeen and Glasgow. His biographer states that since then he has been able to do comparatively little for the advancement of his favorite study.

In June, 1875, Edward remarked: "As a last and only remaining source" (of subsistence), "I betook myself to my old and time-honored friend, a friend of fifty years' standing, who has never yet forsaken me, nor refused help to my body when weary, nor rest to my limbs



"AND HERE I AM STILL."

when tired—my well-worn cobbler's stool. And here I am still on the old boards, doing what little I can, with the aid of my well-worn kit, to maintain myself and my family; with the certainty that instead of my getting the better of the lapstone and leather, they will very soon get the better of me."

It remains only to add that, since the publication of Mr. Smiles's book, the queen has been moved to grant Thomas Edward a pension of fifty pounds a year. All will be glad of this; but we cannot forget that if this man had directed his genius to the work of war, with a tithe of the success he has achieved in enlarging our knowledge of Nature, his reward would have been far greater than it is now!

CORRESPONDENCE.

SPENCER'S CLASSIFICATION OF THE ABSTRACT SCIENCES.

To the Editor of the Popular Science Monthly.

I AM a great admirer of Herbert Spencer, and especially of his wonderful "Answers to Criticisms" in your journal. When he seems entirely caught and inwoven by his adversaries, with one blow of his trenchant blade he cuts the net, and is free.

He is one of the highest of living authorities, and I read with deep attention his two editions of "The Classification of the Sciences," being particularly interested in Table I., "The Abstract Sciences." All of it but two divisions he devotes to mathematics as exactly equivalent to quantitative relations; still, at the present day, it seems an untenable cramping of mathematics to define it as the science of quantity.

A candid note in Mr. Spencer's first edition shows that it was not till after he had actually drawn up this table that he became aware of one of the most important points in the question to be solved.

It is a note to his first great division of mathematics, and says: "I was ignorant of the existence of this as a separate division of mathematics, until it was described to me by Mr. Hirst, whom I have also to thank for pointing out the omission of the subdivision 'Kinematics.' It was only when seeking to affiliate and define 'Descriptive Geometry' that I reached the conclusion that there is a negatively-quantitative mathematics as well as a positively-quantitative mathematics."

All this confession is omitted in the second edition, where, however, the much superior expression "Geometry of Position" is substituted in the table for "Descriptive Geometry," which latter was very apt to be misleading, especially to engineers, from its technical sense, in which sense, of course, Spencer did *not* mean it.

Now let us try to explain, in few words, what the problem was that Hirst so unexpectedly put before Spencer's mind, that you may judge whether "seeking to affiliate" it to a scheme already drawn up was a proper mental condition in which to deal with a question so important, so subtile, so profound.

Geometry, as the abstract science of space, naturally resolves itself into two great divisions, geometry of measurement and geometry of position—geometry quantitative or metrical, and geometry morphological or positional.

As an example of the first, we may take the most ordinary illustration, that of equivalent triangles. Any two triangles having the same base, and their vertices in a line parallel to that base, will be of equal or "equivalent" superficial magnitude. Although the sum of the three sides of the one triangle might be a thousand times as great as the sum of the three sides of the other, they will contain the same number of square inches or square feet. This is a metrical or quantitative proposition; but, on the other hand, many propositions are known which are purely descriptive or morphological. Take the one, perhaps, best known, the celebrated hexagram.

In any circle join any six points of the circumference by consecutive straight lines in any order: the intersections of the three pairs of opposite sides are in a straight line. Or, take any two straight lines in a plane, and draw at random other straight lines traversing in a zigzag fashion between them, so as to obtain a twisted hexagon or sort of cat's-cradle figure: if you consider the six lines so drawn symmetrically in couples, then, no matter how the points have been selected on the given lines, the three points through which these three couples of lines respectively pass will lie all in one and the same straight line. So great an authority as Prof. Sylvester has stated that this proposition "refers solely to position, and neither invokes nor involves the idea of quantity or magnitude." Take another: If any pencil of four rays is cut by a transversal, any anharmonic ratio of the four points of intersection is constant for all positions of the transversal.

Now, Carnot in his splendid "Geometry of Position," and many before and after him, have laid open a whole world of truths of this kind, truths undeniably geometrical in their nature, but founded on the primitive idea of position, and bringing in any idea of quantity only incidentally and afterward. Now, this was evidently a branch of mathematics, but, having made his scheme mathematics only coextensive with quantitative relations, Herbert Spencer must force this under the quantitative rubric, and thus was betrayed into error. Seeing that it was not really positively quantitative, he could only call it negatively quantitative, but in doing this entirely misrepresents it. In Table I. he has, under "Abstract Science:"

"Laws of Relations

that are Quantitative (Mathematics).

"Negatively: the terms of the relations being definitely-related sets of positions in space, and the facts predicated being the absence of certain quantities ('Geometry of Position')."

Now, we contend that there is naturally nothing negative about the matter, and to call it negative is unfairly to wrest it from its proper simplicity in order to force it under a preconceived classification. The primitive and natural idea of position is of any portion of space, as distinct from space in general, and does not depend at all upon any quantitative relations, either positive or negative. But, after this, if we wish to define any position with reference to any other definite known position, we use quantities, coördinates, and by this means we can, by using only positive quantities, e. g., a positive straight line and a positive angle, accurately refer any one point in any plane to any other point in the same plane.

So "the proposition that certain three lines will meet in a point" is not "a negatively-quantitative proposition," as Spencer asserts in his note. It is primarily not quantitative at all, but positional; and, secondarily, if one wishes to look at it in a quantitative light, it is then very positively quantitative, since it asserts that the three lines will run together on a point which may be exactly fixed by positive quantities —its polar coördinates; or, having the point fixed by the intersection of either two of the lines, it asserts, *directionally*, that the third line must go directly through that point. In the same way, the assertion that "certain three points will always fall in a straight line" is primarily an assertion of relative position, in which the relation is defined in the simplest manner by a single positive straight line. The whole question is this: Is not position as simple and primitive an idea as quantity? and is not Spencer in error when he gives its abstract science no separate place, but ranges it under, and tries to make it depend upon, quantity?

GEORGE BRUCE HALSTED, A. B.,
Mathematical Fellow of Johns Hopkins University, late Mathematical Fellow of Princeton College, Intercollegiate Prizeman.

P. S.—Since the above was in print, I have noticed that Arthur Cayley holds views on this subject very much opposed to those of Mr. Spencer. (*See* Cayley's "Sixth Memoir on Quantics," in the "Philosophical Transactions.") G. B. H.

It has been remarked of Mr. Herbert Spencer that he does not stand well with the experts—men trained in specialties, and who know their subjects at first hand, and through and through. This is thought to be a formidable charge, and it would be formidable if it were true, and the experts agreed among themselves. But when they coincide in nothing but in differing from Mr. Spencer, we may be moderately reassured, and venture to think upon the questions they raise, without the sense of being crushed to the dust by the weight of authority.

This is not the first time that Mr. Spencer's note, or, as our contributor calls it, his "confession," has been attacked by mathematicians, and in such a way as to admonish him that, as this world is constituted, it is not always wisest to be very candid. It has ever been a rule with him carefully to acknowledge the aid he has received from others—a practice which, as in the present instance, has exposed him to misunderstanding and misrepresentation. Mr. Halsted recognizes that, by "Descriptive Geometry," Mr. Spencer did *not* mean those technical methods of geometrical construction to which engineers apply the name; yet no less a mathematical expert than Mr. Chauncey Wright—the pride of Cambridge, and whose biography we are soon to have—attacked him a dozen years ago, in the *North American Review*, on the very passage here dealt with by Mr. Halsted, but on the opposite ground that such *was* Mr. Spencer's meaning of Descriptive Geometry. And having assumed that Spencer meant a mathematical art which he was trying to classify as abstract science, Wright insinuated that by his acknowledgment to Hirst he was ignorant even of this. It was a disingenuous piece of work. Mr. Wright was then hunting through Spencer's various books in search of flaws to work up into a sensational article, and he was not very particular how he did it, so he could make a telling point. As his note was liable to such misconstruction, Mr. Spencer very naturally withdrew it in a second edition, and substituted for the title first used one less liable to be misunderstood.

And now has not Mr. Halsted also somewhat misapprehended this memorable note? If Mr. Spencer was not referring to the art of Descriptive Geometry, as Mr. Halsted admits he was not, then he must have been referring to the system of theorems in the science of pure mathematics which has

grown up under the name of "Descriptive Geometry." But where is the evidence that he was ignorant of these theorems? He certainly does not say that he was made acquainted with them by Mr. Hirst, but simply that he was first informed by him that they had been grouped into "a separate division of mathematics." Why he did not know of this is readily explained, as the title Descriptive Geometry had never been adopted in England for the subject to which it had been applied, from Monge, to Reye on the Continent; and its modern restricted use was very naturally known only to professed mathematicians. What Prof. Hirst put before Mr. Spencer was, therefore, not any new mathematical problems or principles which he found it necessary as an afterthought to thrust into a previously-formed mathematical philosophy, but only the recognized differentiation of a certain mathematical province.

As for the non-quantitative mathematics, we fail to see that Mr. Halsted gets up much of a difference with Spencer. Mr. Halsted thinks that the "Geometry of Position" does not involve the notion of quantity, and Mr. Spencer thinks the same. But the experts of "Harvard" and of "Johns Hopkins" are squarely at issue on this point. After making his case against Mr. Spencer on a false interpretation of what he said, Mr. Wright admitted that, perhaps, after all, he did not mean that—possibly, instead of a branch of the engineer's art, Spencer was referring to "certain propositions in the higher geometry concerning the relations of position and direction in points and lines." But he opens a battery of sarcasms upon the idea of non-quantitative mathematics, and says of these geometrical propositions that they "cannot be made to stand alone, or independently of dimensional properties." Spencer was thus attacked by a skilled mathematician a dozen years ago for taking substantially the same ground that Mr. Halsted now advocates.

In regard to the terminology of the subject, Mr. Halsted encounters the difficulty which always arises when knowledge outgrows old definitions. No doubt, if positional geometry is non-quantitative, and is still a branch of mathematics, we should have a new definition of mathematics; but it is much easier to discredit the old one than to replace it by a better. Why does Mr. Halsted continue to apply the term geometry, which, by its very structure and etymology, implies measure and quantity, to that which has no quantity? Mr. Spencer evidently saw the difficulty; but, rather than attempt to redefine mathematical science, he preferred the alternative of marking off the newly-recognized province by a title that excluded the element of quantity—that is, he called it negatively quantitative. Mr. Halsted does not like this term. Speaking of a certain proposition given as an illustration by Spencer, he says: "It is not 'a negatively quantitative proposition,' as Spencer asserts in his note. It is, primarily, not quantitative at all." But what does Mr. Halsted suppose Mr. Spencer means by "negatively quantitative," unless he means not quantitative at all, or the denial and exclusion of quantity? Let us observe exactly what Spencer says: "In explanation of the term 'negatively quantitative,' it will be sufficient to instance the proposition that certain three lines will meet in a point, as a negatively-quantitative proposition, since it asserts the *absence* of any quantity of space between their intersections. Similarly, the assertion that certain three points would always fall in a straight line is 'negatively quantitative,' since the conception of a straight line implies the *negation* of any lateral quantity or deviation." The italics are ours, but the statement is sufficiently explicit. The absence or negation of quantity is as strong an expression as could be used for no quantity at all, or that which Spencer calls negatively quantitative. Mr. Spencer designates the "Geometry of Position" as of this kind, and yet Mr. Halsted imputes to him the error of ranging it under and trying to make it depend upon quantity.

Mr. Halsted reports that, in his last bulletin, Cayley stands opposed to Spencer's views. It is to be hoped that he understands him; but what is his relation to Wright and Halsted?

And now, apologizing to our readers for introducing this remote discussion, and passing it off under the head of popular science, we call upon the heirs and repre-

sentatives of Johns Hopkins to hurry up their proposed *Mathematical Journal*, that there may be a proper place for the consideration of questions like this.

INSECTS AND FLOWERS IN COLORADO.

To the Editor of the Popular Science Monthly

THE communication of Mr. Meehan, in your January number, and the request at its close, are herewith responded to by the entomologist in question—one to whom we may fairly apply the line—

"[Though] young in years, in sage experience old."

As the letter supplies the information called for, you will, doubtless, wish to print it in full, and I inclose it for that purpose.

Very truly yours, ASA GRAY.

CAMBRIDGE, MASS., *January* 22, 1877.

DEAR DR. GRAY: In the January number of THE POPULAR SCIENCE MONTHLY, Mr. Meehan takes some exception to your note in the *American Journal of Science* for November in regard to the comparative abundance of insects and flowers in the Rocky Mountains of Colorado. He asks particularly for a "list of the *Hymenoptera* and *Lepidoptera* that are abundant enough in the particular part of the Rocky Mountain region covered by [his] experience, to probably act as cross-fertilizers of flowers, noting those which may perhaps be introduced since 1871." The route referred to is "through Golden City and Idaho Springs to South Park, thence to Pike's Peak and the Garden of the Gods. . . . to Denver over the level plateau known as the 'Divide.'" In 1873 he speaks of having visited Gray's Peak, and must, therefore, have passed up Clear Creek and through Georgetown. In 1872 I spent three months in the mountains of Colorado in company with Dr. C. C. Parry. We walked up through the cañon of Clear Creek to Idaho Springs, Georgetown, and Empire City. At the latter place we established our headquarters, and there most of my collecting was done. Frequent trips were made to the neighboring mountains and cañons, including the ascent of Gray's Peak. In the fall a trip was made to Middle Park. The summer of 1873 I spent in Western Wyoming with Captain Jones's exploring party. In 1874 I again visited Colorado, but spent most of my time on the plains at the base of the mountains between Boulder City and Cañon City, though I made several trips into the mountains up Boulder, Left Hand, and Clear Creeks. In 1875 I spent some time in Utah among the Wahsatch Mountains. It has always been my experience that, wherever flowers were plenty, so were insects. Consequently, I have always found a botanist to be most excellent company on a collecting-trip. As my opportunities were better in 1872, my remarks refer mostly to that year, and it is not at all likely that any of the species I then noticed had been introduced. Lists of the *Coleoptera*, *Lepidoptera*, *Hymenoptera*, and *Orthoptera*, collected on this trip, have been published in the "Proceedings of the Davenport Academy of Natural Sciences," vol. i.; but I will here call attention to such of the species as seem to be most useful in the fertilization of plants:

HYMENOPTERA.—*Bombus flavifrons* (Cr.) was perhaps the most common and generally distributed of the bees, though it seems to be quite a mountain species. I always found it wherever there was a patch of flowers in an opening in the timber, or at the timber-line. I did not notice that it confined itself to any particular kind of flower. It may have done so, but I do not remember it. In company with the above, though somewhat less abundant, I found *B. terricrius*, the species mentioned by Mr. Meehan as confining its attention to *Polygonum bistorta*, but I did not notice this peculiarity. Both of these species were found abundantly at Empire City and on the surrounding mountains. Besides these, *Bombus borealis* (Kirby), *Apathus insularis*, *Anthophora terminalis*, *Megachile gentilis*, *Menumetha borealis*, were found in abundance in the district referred to by Mr. Meehan. Of other *Hymenoptera* collected in this district, I mention the following, which probably were of more or less assistance in the fertilization of plants: *Calliopsis* (sp. ?), *Prosopis affinis*, *Agapostemen texanus*, *Colletes consors*, *Vespa diabolica*, *Ammophila luctuosa*, *A. communis*, etc., besides a considerable number of smaller species as yet undetermined. For a more complete enumeration, I must refer you to the list above mentioned. To

show that I am not the only one who has noticed an abundance of *Hymenoptera* in Colorado, I would call your attention to the papers of Mr. E. T. Cressen in the "Proceedings of the Entomological Society of Philadelphia," and particularly to a "Catalogue of *Hymenoptera* from Colorado Territory," published in vol. iv. of those "Proceedings."

LEPIDOPTERA.—In the list referred to I have enumerated forty-seven species of butterflies, which I collected, with but one exception, in the mountains. I have never anywhere seen butterflies so abundant as they were in the valley of Clear Creek, between Golden City and Idaho Springs, on July 1, 1872. The air seemed literally to swarm with them. I cannot imagine how the entomologists of Mr. Meehan's party found them so scarce. Wherever there were flowers, I was sure to find butterflies, though, of course, they showed a preference to some kinds. Of the *Heterocera* I brought home over sixty species, mostly undetermined; but this is no indication of the actual number occurring, for I took no pains to hunt them, and only preserved what came to me.

The common morning lined sphinx (*Deilephila lineata*) was frequently seen at dusk, hovering about various flowers, being especially fond of the yellow thistles. I do not now recall any peculiarity regarding the other species, except that they were quite plenty. Perhaps 1872 was an unusually favorable season; but Mr. Theodore L. Mead writes that in 1871 he spent four months in Colorado, mostly in the South Park region, where he collected over 100 species and 3,000 specimens of butterflies, and 4,000 specimens of beetles, etc. I believe Mr. Mead has published an account of his observations on Colorado butterflies in the zoölogical report of Lieutenant Wheeler's explorations west of the 100th meridian. I would also refer you to an article on Coloradian butterflies, by Tryon Reakirt, in the "Proceedings of the Entomological Society of Philadelphia," vol. vi., 1866, and to the more recent works of W. H. Edwards, and others.

Although Mr. Meehan does not mention them, I have an idea that the *Coleoptera* and *Hemiptera* are often quite active agents in the fertilization of plants. Certainly the number of species of these orders found in flowers was very great, and it is more than likely that in going from flower to flower they carry some of the pollen with them. The *Meloidæ*, *Chrysomelidæ*, *Cerambycidæ*, *Cleridæ*, *Malachidæ*, *Mordellidæ*, etc., were especially noticeable by the large number of species and individuals. *Trichodes ornatus* (Say) was exceedingly abundant in the flowers of *Potentilla fissa*, and, after that had generally gone out of flower, on the flowers of the white and red geraniums and other plants. Owing to the fact that at the time I made these collections I knew the names of neither the plants nor insects, I cannot now remark more definitely on their habits. A full list of the species collected will be found in the "Proceedings of the Davenport Academy," vol. i.

I think what I have said shows that there is no unusual scarcity of insects in the Rocky Mountains of Colorado, at least wherever there are flowers. It should not be overlooked, however, that within the Rocky Mountain regions there are arid districts where neither insects nor flowers are particularly abundant; and also that a similar state of affairs exists in a dense pine or spruce forest. Wherever flowers are plenty in the Rocky Mountains, so are insects always; but the reverse is often not true, for I have frequently known certain insects to be exceedingly plentiful where there were no flowers. The "entomologists" of Mr. Meehan's party were certainly very unfortunate in finding so few insects. I believe Mr. Morrison, of Cambridge, an excellent collector, intends spending next summer collecting the insects of Colorado, and he will be able to add his testimony to the case.

Mr. Meehan has certainly read Lieutenant Carpenter's paper in Hayden's Report for 1873 very carelessly, or he would have seen that the five species of butterflies he speaks of as being the "doings of a whole season" were all Alpine, and collected above the timber-line, a region which a little further on he rules out of the discussion. It is certainly true that these *Alpine* "*Lepidoptera* are undoubtedly peculiar to high latitudes and great elevations;" but

the species found lower down in the cañons often show a greater affinity to Mexican and Californian types. I was more fortunate than Lieutenant Carpenter, and took over twenty species of butterflies above the timber-line.

I have endeavored to show that sometimes at least insects are quite plentiful in the Colorado mountains. They are certainly more plentiful in the mountain-regions than on the plains.

Yours very truly,

J. DUNCAN PUTNAM.

DAVENPORT, IOWA, *January* 10, 1877.

EFFECTS OF THE WAR ON THE INCREASE OF POPULATION IN THE LAST DECADE.

To the Editor of the Popular Science Monthly.

THE Superintendent of the Ninth Census, while showing the causes of loss in population produced by the late war, neglected to point out the actual decrease incident to this cause, as shown by the State censuses of 1865.

The retarding influence may be seen by reference to the States of New York and Massachusetts.

In the former State, whereas the regular increase for each period of five years had been nearly 500,000, from 1860 to 1865 there was a *decrease* of 29,000. From 1865 to 1870 there was an increase of 529,000. —("Manual" for 1870.)

In Massachusetts the increase of population from 1850 to 1855 was 138,000; from 1855 to 1860 it was 90,000; from 1860 to 1865, 36,000; from 1865 to 1870, 190,000; and from 1870 to 1875, 194,000. The regularity of increase in the State is shown by the fact that the difference between the actual population in 1870 and that computed on the supposition that the increase was in arithmetical progression was only 2,120.—("Massachusetts State Census" for 1875, vol. i., p. xxxii.)

In these two States, therefore, the increase of population during the war-period was only 7,000, while in the next five-year period it was fully a hundred times as great. The population of these two States was over 6,000,000, or more than fifteen per cent. of the total population of the United States.

As it may be urged that these States suffered heavily in loss of immigration, we will attempt to estimate their actual loss in this respect. The total loss of immigration is estimated ("Ninth Census," vol. i., p. xix.) at 350,000. If we suppose the immigration into a State to be proportionate to the foreign population of that State, the proportion of loss in immigration for these two States will be 27 per cent. of the whole loss, or about 94,500. Omitting the loss in immigration, therefore, the total gain of these two States will be 101,500. Even if we further suppose that these States suffered another special loss of 48,500, the total gain would still be only 150,000. Multiplying this by 8, the ratio between the increase of population in these States (700,000) from 1865 to 1870, and the estimated increase of the United States for the same time, we get for the total gain of the country, without considering the loss in immigration, 1,200,000. Deducting this loss, we have for the entire gain 850,000.

We have no reason to suppose that New York and Massachusetts were especial sufferers during this period. Many of the Southern States probably suffered more, especially in loss of negro population, which amounted to half a million during this period ("Ninth Census," vol. i., p. xviii.). There is, then, no reason to suppose that the above estimate falls far short of the truth. Even if the estimate is increased to 1,500,000, which seems improbable, the population of the country in 1865 would still fall short of 33,000,000. This would indicate for the succeeding period of five years an increase of 5,500,000, which is somewhat above the average. That this large increase is actual is rendered probable by the corresponding large increase in Massachusetts and New York for the same time.

ALEXANDER DUANE, *Union College.*

EDITOR'S TABLE.

BIOLOGY IN COMMON SCHOOLS.

WE call attention to the important paper sent to us by Prof. Huxley, on the study of biology. Science, as the highest expression, and the most accurate and methodical form of knowledge, is pressing its educational claims; and Prof. Huxley here offers us some very important considerations on the nature of biological science, and why and how it should be taken up in institutions devoted to mental culture. Perhaps no living man can speak with more authority upon this subject than Prof. Huxley, not only from his profound familiarity with this branch of knowledge, and his recognition of the demands of scientific education, but because of his own broad and liberal culture, which protects him from narrow views, and enables him to assign their relative values to different branches of study.

Nevertheless, when he comes to his fourth and final question as to "*when* biological study may be best pursued," we think he is less satisfactory than in dealing with his previous questions. This, as we look at it, is much the most important inquiry, and deserves a fuller investigation than Prof. Huxley had time to give it; while what he did say, from the use that will inevitably be made of it, will be liable to do more harm than good. Prof. Huxley is decided in the conviction that biological study should be made a part of ordinary school-training, and that it can be carried out with ease and profit to those who are taught. But he anticipates and yields to an objection which, as things are, will be certain to work the utter defeat of the study in "ordinary schools," and an objection, to the force of which, we think, he should not have made the slightest concession. He says, "There are difficulties in the way of a lot of boys making messes with slugs and snails." Prof. Huxley has here put his finger upon what is the formidable obstacle we have to encounter in the study of the real objects of Nature in common schools. Books, lessons, and recitations, are cleanly, and give no trouble; objects as matters of observation and study by individual pupils are dirty, cluttering, and untidy, if not messy, sloppy, and nasty. Experiments are tolerated, now and then, for an hour, when carried on by the teacher at one side, behind tables, or where assistants can clean up; and minerals and specimens are also allowed when they can make a show in inaccessible cabinets; but apparatus and objects of any sort, for the use of individual pupils — even microscopes, minerals, or plants—are the bore of the school-room, and the torment of tidy, methodical, and routine teachers. The superstition that education is purely a matter of books is profound and inveterate—so much so, that even the employment of blackboards, maps, and globes, is looked upon as something in the way of concession to the spirit of modern innovation. The ideal of the school is pure wordiness, with a minimum of bother from anything not included in the text-books.

As regards biology, of course, the difficulty takes its most aggravated form. There is a deeply-rooted and universal prejudice against the whole tribe of lower creatures, typified by Prof. Huxley's "slugs and snails." Our readers who have glanced at the biographical sketch, in the preceding pages, of an eminent Scotch naturalist, who has done noble work for science in his locality, will remember that he

was turned out of three schools before he was seven years old, in consequence of his irrepressible passion for collecting the curious natural objects which fell in his boyish way. But the feeling which led to the treatment of little Tom Edward is far enough from being confined to his brutal and besotted teachers. We have seen cultivated, high-school instructors, and parents claiming to be liberal and intelligent, who would cry out with horror to see their children touch such repulsive things as worms and frogs, and threaten them with a thrashing if they brought them in or around the house. It is this vulgar and absurd prejudice that stands in the way of anything like rational biological study in our schools. Undoubtedly, it is very nice and pleasant to learn natural history out of textbooks full of pictures, and abounding in pretty anecdotes about animals; but we can only get the study, in place of this, of actual living creatures by battling with and conquering the foolish infatuation of people in regard to the repulsiveness of the inferior forms of life. Unperverted children are fond of them, and this feeling should be cherished and encouraged, and made available as an impulse in early study. Prof. Huxley knows how to deal telling blows at the various pestilent bigotries of society that stand in the way of its intellectual progress; and we should have been better pleased if he had denounced this prejudice as it deserves, rather than make tacit terms with it, as a "difficulty," because progress is only made as difficulties are overcome and got out of the way.

As to human physiology, we doubt if it is the proper door to biology, either for young or old—it is putting the complex before the simple; and, although viscera may be had at the butcher-shops, we fail to see what is gained on the score of "messiness" by substituting them for "slugs or snails," or the simpler forms of life that can be procured anywhere. Prof. Huxley says that "plants do not make a mess—at least, they do not make an unpleasant mess," but the quality of the mess is not the important thing. The study of plants is resisted in schools, and, when attempted, is often abandoned, simply because of this circumstance; and, when the principle has been once conceded, as in the case of plants, the difficulty practically disappears in regard to animate things. If there is the slightest interest in the subject, there need be no trouble. Classes of children a dozen years old can go through Prof. Morse's admirable "First Book of Zoology," collecting numerous specimens of insects, shells, and creatures found in ponds and puddles, and, if his directions are followed, which may be easily done, there will actually be less litter and inconvenience than is usual with the study of plants. The "difficulty," in fact, is not real or intrinsic in the conditions of the case, but, as we have had occasion to notice again and again, it comes from the stupid ignorance and fussy meddlesomeness of parents, who bully the teachers at every deviation from the "horrid demnition grind" of book-lessons and recitations in the schools. The fact is, if we ever get the study of Nature into the schools, it can only be by breaking down the superstitions by which they are dominated; the deadly order, by which Nature is kept out; and by a larger recognition of individual aptitudes, and much freer opportunity for the observation and study of natural objects.

SOME QUESTIONS ANSWERED.

A PUBLIC appeal was made, through the *Tribune*, by Rev. Dr. Deems, to the editor of THE POPULAR SCIENCE MONTHLY, to make good certain statements contained in the criticism of Dr. Taylor's letter. Dr. Deems avows that his "questions are submitted for information," but we suspect he is not half

so ignorant as he pretends; as others, however, are also asking for explanations, we will consider his most important points.

We had remarked: "A theory is said to be demonstrated when it brings all the known facts into agreement, explains them, excludes all other interpretations, and is consistent with itself and all that is understood of the ways of Nature." Dr. Deems asks: "Did Prof. Huxley 'bring all the known facts into agreement?' Did he show that his theory was 'consistent with all that is understood of the ways of Nature?' Did he not tacitly admit that he was not able to show that his theory was 'in agreement' with what physical astronomy teaches us of the 'ways of Nature?'"

Prof. Huxley certainly made no such admission in any form or degree, and we are at a loss to see how his utterance or the report of it can be so construed. Possibly it is because he dismissed the subject somewhat curtly, which was interpreted into an unwillingness to face it, accompanied by the further inference that he was unable to do so. But it is to be remembered that the question was thrust upon him by editorials in leading newspapers and by private communications, and was not embraced in the plan of his argument, to which he had not half time enough to do justice. He was, therefore, compelled to be brief; but the case was squarely met. It had been objected that evolution cannot be true because physical astronomy proves that there has not been time enough since the cooling of the earth for the slow processes of life-unfolding to have taken place. To this Prof. Huxley replied, first, that he had already considered the subject in an address before the Geological Society of which he was president, and had showed that the "teachings of physical astronomy" as against geological time are not sound; and he, moreover, knew that this address was accessible to all interested, as it had been circulated by thousands in this country in his volume of "Lay Sermons." Is this to be construed into inability to maintain his theory against the objections raised in the name of physical astronomy?

Secondly, Prof. Huxley replied that, granting the validity of the case made out by the "physical astronomers" (which, of course, he did not grant), even then the biologist has little reason to trouble himself about the result. His proof of evolution comes from another source, and demonstrates to him that there must assuredly have been time enough for its occurrence. It has been customary to affirm that the evolution of life has proceeded at a very slow rate, and required vast periods of time; but what is the basis of the assumption? It is that the series of living forms is distributed through extensive deposits of stratified rocks which the geologist says it has taken vast periods of time to make, and, as the course of life-changes has been coeval with the course of strata-deposition, if the geologist is right, evolution must have been slow. But, if the geologist revises his data either way, the biologist will simply accept the result, and occupy the time. He only says: "There, in the vast succession of rocks, is our proof of evolution as a matter of fact; the geologist and the physicist may settle the question of time between them, and inform us, if they can, how long it has taken." And what is there here of tacit concession that his case was weak as against the "teachings of physical astronomy?"

Let us now briefly examine that case, and see how much occasion for anxiety it gives to the adherents of the doctrine of evolution. "The teachings of physical astronomy" here referred to mean the mathematical and physical speculations of Sir William Thomson in regard to the rate of cooling of the sun and of the earth, the retardation of the earth's rotation by the drag and

friction of the tides, the influence of melting polar ice, etc., speculations that have by no means taken their place among the established principles of physical astronomy. But Sir William Thomson concludes that a limit is to be put to the time during which life can have existed upon the earth. Yet it must not be supposed from this that his chronology at all approximates to that of Archbishop Usher. He assumes, and draws his arguments from, the nebular hypothesis, and, instead of starving the geologists in their allowance of time, it must be confessed that he deals with them very liberally. He says he believes that "the existing state of things on the earth, life on the earth—all geological history showing continuity of life—must be limited within some such period of time as one hundred million years." "Some such period of time!" This is sufficiently vague, and raises the query, "Does it mean that the time may have been two, three, or four hundred million years?" Prof. Thomson himself puts this interpretation upon it when he says elsewhere of the high surface-temperature which made life impossible: "We must still admit some limit, such as fifty million years, one hundred million years, or two or three hundred million years ago. Beyond that we cannot go." And, again, he expresses the opinion that the sun has not really illuminated the earth for a period of five hundred million years.

But are the geologists so very badly cramped by these limitations—even assuming them to be established? The total thickness of stratified rocks containing traces of life may be taken, on the best geological authority, as one hundred thousand feet, or nearly twenty miles. The deposit of one hundred thousand feet of stratified rock, in one hundred million years, implies that the deposit has taken place at the rate of about one-eighty-third ($\frac{1}{183}$) of an inch per year. If the "some such period" was double that time, then a hundred and sixty years would be allowed for the accumulation of an inch of sedementary rock; or, if three hundred million years are taken, the rate of stratified growth would be one-two-hundred-and-forty-ninth ($\frac{1}{249}$) of an inch annually. This is a very moderate pace, and certainly affords little ground of complaint on the part of the biologist that he is pinched for time by the geologist and physicist. Prof. Huxley, therefore, had not the slightest reason for admitting that his theory was not "in agreement" with what physical astronomy teaches us of the "ways of Nature."

Continuing the same line of thought, Dr. Deems quotes our remark that "it is a demonstrated fact that life has existed on the globe through periods so vast as to be incalculable," and asks: "Where, when, and how, was this ever 'demonstrated?' Has it not been shown that within a period not 'incalculable' life could not have existed on this globe?" We certainly did not mean that the resources of arithmetic are insufficient to express the time during which life has existed upon earth, but we did mean that the periods are so vast and obscure as not to be brought within definite estimate or "calculation." And of this the whole science of geology affords the demonstration. If the rocks have been formed in succession, as geology has proved, and twenty miles of strata have been piled over the earliest-appearing forms of life, then the time since living creatures came has been indefinitely vast, and that the periods are not amenable to anything like "calculation" or trustworthy estimate is shown by the way the subject is dealt with in our most authoritative geological works. Where uncertainty enters largely, positive calculation is excluded, and accordingly we find that when the ablest geologists approach this subject they either abstain from any attempt at calculation, or they refuse to deal with it, in terms of years and talk of eras, epochs, and cycles. Prof. Dana speaks

"of the relative lengths of the ages and periods, or their time-ratios," and says "future discovery will probably enable the geologist to determine these ratios with far greater certainty and precision. Although geology has no means of substituting positive lengths of time in place of such ratios, it affords facts sufficient to prove the general proposition that *Time is long.*" This "proof" we hold as demonstration; and the substitution of "relative lengths of ages and periods" for "positive lengths of time" certainly justifies the use of the term "incalculable" as applied to them.

We had said that "it is a demonstrated truth of Nature that matter is indestructible," and Dr. Deems asks: "When, where, and how, was this ever 'demonstrated?' Even if it be true that matter is indestructible, can it be demonstrated? Dare any but an infinite intellect make such an assertion?" It was a theory held for thousands of years that, in the workings of Nature, matter is constantly created and destroyed—comes out of nothing and goes back to nothing. Modern science brought this theory to the test of experiment, and showed that it was erroneous. No facts were found to sustain it, but, on the contrary, all the facts prove the truth of the opposite theory, that the changes of matter are changes of form, and that matter itself is indestructible. A theory is demonstrated when all the facts verify it. Every experiment and observation in the whole body of science, physical and chemical; every fact, induction, and deduction, reached by the human mind, confirms the truth of the indestructibility of matter, and there is no shadow of evidence against it. What is this but a demonstration? And, if the proposition is sustained by this high degree of proof, we fail to see what there is of "daring" in giving it a label that expresses the fact.

There remains another important point suggested by a question of Dr. Deems, which, for want of space, we put over to next month.

PROFESSOR MORSE'S LECTURES.

Prof. Morse has been quietly delivering a course of four lectures, in the large hall of the Cooper Institute in this city, on "Evolution." We say *quietly*, because there has not been much said about them by the press, as they have been given in the admirable series of free Saturday evening lectures that run through the season, and have become matters of course with the lecture-going public. Yet these lectures of Morse's might well have attracted the prominent attention of our newspapers, as they were unequaled in the skillful presentation of biological facts and principles commonly dry and forbidding, so as to be perfectly understood and intensely relished by large audiences of non-scientific people. Prof. Morse has remarkable gifts as a lecturer, and in the field of science is without a peer on the American platform. In the first place, he knows his subject thoroughly, and is charged to overflowing with its latest and freshest facts and illustrations. In the second place, he has a faculty of rapid and accurate delineation of the forms and structures of life that he is dealing with, that is unique and unapproachable by any other man that we ever saw work with the blackboard. He chalks as fast as he talks, and while he talks, and without spoiling his talking; and by his marvelous creations he holds his auditors as closely through their eyes as their ears. His manner as a speaker is, moreover, free, colloquial, spirited, and impressive, and his utterances vigorous, pointed, and racy. These arts are, however, all subordinate to the solid work of instruction. The last lecture of his course, although dealing apparently with technical and formidable scientific facts concerning the relations of

organized creatures, living and extinct, was yet nothing less than a delightful entertainment. His vast audience of three thousand people were held spell-bound and so closely occupied with the interest of the discussion that the attempt at cheering was repressed as an interruption. Something, however, was due in this remarkable effect to the interest of the theme, and the rapid liberalization of public opinion that has latterly taken place; for fifteen years ago it would neither have been possible to get such a multitude together to listen to the uncompromising defense of evolutionary doctrines, nor could Prof. Morse have kept such a crowd in control even if they could have been got together.

BAIN ON EDUCATION.

THE readers of the MONTHLY will hardly need any reminder as to the importance of carefully perusing the first article in our present number, concluded from last month, on "Education as a Science." Every art, when science comes to be applied to it, undergoes something like a revolution, as the principles which control it are gradually working out into such clearness that they can be followed in practice. And however important this fact may be in relation to the industrial arts, it becomes of infinitely greater moment when the object to be attained is the cultivation of the human mind. It is difficult to exaggerate the benefits which must follow the establishment of scientific principles for regulating the work of education, and every valuable contribution to this end is entitled to the most serious and sympathetic consideration.

Hitherto the dictators of educational method have been metaphysicians. Having taken possession of the province of mind, they have claimed to be law-givers in all that pertains to its management. But their method is vicious and misleading, from its incompleteness and want of a secure scientific basis. It has neglected the corporeal side of human nature. As mind is never manifested except by and through a material substratum, no analysis of it, no statement of its modes and conditions of working, can be scientifically grounded, or true to Nature, or full and trustworthy in its elements, that does not take into constant and essential account the organic concomitants of intellect and feeling, or the bodily organism. By doing this, mental science has not only been widened and deepened, but placed upon a positive foundation. Prof. Bain is a pioneer, and an eminent authority, in this great reform of mental philosophy. His principal works upon the human mind, "The Senses and the Intellect," and "The Emotions and the Will," are comprehensive expositions of mental science from this point of view, and have thoroughly prepared their author for treating the applications of scientific psychology to the practical business of culture. Indeed, no better vindication of this method of treating the subject of mind can be furnished than that which the reader will gather from his last essay on the conditions of mental acquisition in the paper herewith published. The vagueness of metaphysics here disappears, and the various forms of mental effort are graded, not with reference to abstract considerations, but with reference to the variable vigor and unequal plastic power of the corporeal system. The most important questions of practical education can only be resolved from this point of view, and from this point of view they are capable of being resolved in a way to command the confidence of teachers, and guide the operations of the school-room. Prof. Bain is expected to pursue the subject in future into the details of educational practice, and the readers of the MONTHLY will probably hear from him again before very long.

LITERARY NOTICES.

FRAGMENTS OF SCIENCE: A SERIES OF DETACHED ESSAYS, ADDRESSES, AND REVIEWS. By JOHN TYNDALL, F. R. S. Fifth edition. New York: D. Appleton & Co. Pp. 625. Price, $2.50.

PROF. TYNDALL'S position in the world of thought, at the present time, is one of very marked individuality, and there go several strong factors into the composition of that wide and powerful influence as a thinker which he has exerted upon the mind of the period. In the first place, the age is scientific to so great a degree that all human interests are more disturbed by this agency than ever before. Prof. Tyndall's scientific acquirements and training are therefore in harmony with the great intellectual movement of which he has become a leader and representative. His chosen field of labor, moreover, that of physics, is the one which people generally are best prepared to appreciate, while his ingenuity and fertility in devising new and striking experiments for the illustration of facts, and the proof of principles, always compel attention to what he has to offer. Again, his consummate mastery of the arts of exposition, the clearness and beauty of his statements, and the high literary finish of all his work, give him the command of cultivated minds wherever English is read. Equally important, also, in any estimate of Prof. Tyndall's power, is that fearlessness of spirit, and unflinching allegiance to what he considers the truth, that give boldness to his utterances, and carry him to the front of the conflict, in which science struggles with the forces of ignorance, prejudice, and superstition. These elements, of course, are not equally combined in all his productions. In his scientific memoirs we have only the record of laborious and painstaking researches, but they are always elegantly written. In his volumes upon "Heat" and "Sound" we are chiefly struck by the lucid and methodical exposition, interspersed with poetic touches and expressions of fine feeling, awakened by the study of Nature's deeper harmonies, and which are a constant source of pleasure to the student. But it is in his various miscellaneous papers, some of them didactic, some controversial, and others devoted to the development of advanced opinions in which he is deeply interested, and all of them with a scientific substratum, and exhibiting the best excellences of his eloquent style, that we shall find the chief secret of the hold he has obtained upon all classes of readers. These papers were collected, a few years ago, in a volume entitled "Fragments of Science," which proved one of the most popular of his works. It passed through four editions, and the fifth now appears, greatly enlarged by recently-published articles, and containing one hundred and ninety-three pages of matter not found in the former American edition. Prof. Tyndall has rearranged the work, grouping together the more scientific articles in Part I., and the controversial discussions in Part II., to which there is a special and able introduction. All the articles have been carefully revised, with a view to making them, in the highest degree, clear and accurate. Commendation of this work is superfluous, but it is one of the volumes that wide-awake readers cannot well do without, and which is always ready to furnish instruction and entertainment for an odd hour.

TOLLHAUSEN'S TECHNOLOGICAL DICTIONARY. Part I., French-German-English; Part II., English-German-French; Part III., German-English-French. New York: Holt & Co. Price, $3.50 per vol.

THE compilers of general dictionaries of two or more languages have hitherto given but little thought to secure either fullness or accuracy in their vocabularies of technical terms, especially those employed in the useful arts. Such terms having no place in literature proper, and the existing dictionaries being designed mainly as keys to the literature of the various languages, the defect of which we speak becomes, under the circumstances, venial. But we are from day to day coming into closer industrial relations with the outer world, and the need of such a work as that before us has long been felt. The author of this work has spared no pains to make his dictionary complete and accurate, and he is to be congratulated upon the success with which he has performed his very difficult task. The first part of the work (French-German-English) embraces some 65,000 technical terms and

phrases, the second part (English-German-French) about 76,000, and the third (German-English-French) over 90,000. As was inevitable in a work involving so much research, errors are not wanting, and a multitude of technical terms have been omitted. Nevertheless, the author has rendered an inestimable service to the world of letters in the compilation of this dictionary; its defects will disappear under revision, as new editions are called for. In the mean time we are very well satisfied with the work as it stands, and can heartily commend it as a trustworthy guide to the synonomies of technical terms in the three foremost languages of modern industrial life.

PRINCIPIA, OR BASIS OF SOCIAL SCIENCE: Being a Survey of the Subject from the Moral and Theological, yet Liberal and Progressive Standpoint. By E. J. WRIGHT. Philadelphia: J. B. Lippincott & Co. Pp. 524. Price, $3.50.

THE activity of modern speculation on social subjects, while yet there are so few principles established for the guidance of thought, has led to the widest and wildest diversity in the treatment of this class of questions. This is perhaps the highest sphere of intellectual liberty, for in most other departments of thought there are restraints which come from more or less settled ideas. Thus in religion there are established creeds; in practical politics, constitutions, precedents, and the body of laws; in history, canons of interpretation; in science, facts, generalizations, and determined methods—all of which exert a regulative and controlling influence over the speculative tendency. But in the social field very little help comes from any such sources, and the fertile thinker is as free to spin theories and excogitate a philosophy as if he had been the first to start inquiry in this domain. That principles will at length be established to direct the course of investigation, we are not permitted to doubt; but, thus far, the chaos of social philosophy, and the conflict of social doctrines, are the most striking facts in regard to them.

Mr. Wright has made an earnest book, which is pervaded by an excellent spirit and noble aspirations, but his views are original and independent, and he has done his own thinking throughout, from his exposition of a radical and thorough-going socialism down to the punctuation of his volume, which he has carried out according to his own rules. So full a freedom of treatment ought to favor originality of suggestion and freshness of opinion, and the book will accordingly be found to contain many ingenious ideas, and to abound in hints and statements which will find a useful place in the future development of the subject. The author makes no large claims for his work, but simply submits it to the common-sense of his readers for what it may be worth in helping them to the study and understanding of social questions; and "hopes that, if the public cannot tolerate these writings as a work of science, they will, at any rate, tolerate them as a kind of sermon to politicians and statesmen."

Mr. Wright classes the elements or activities of man's social life in six categories or units, as follows: There is, first, the individual; second, the family; third, the social circle—by which he means groups of affiliated or closely-connected families; and, fourth, the precinct—by which he means to designate the neighborhood principle. The precinct is a fundamental idea in the social series which the author develops with special prominence. "Precincts," he says, "are neighborhoods organized into civil governments; they are territories *within* territories; they are *parts* of a tribe or nation, and are not self-existent. In other words, precincts are the organizations of the neighborhood principle in civil government. They might be compared with the 'States' of the American Union by calling them very small and *reformed* 'states.' The precinct is the fourth fundamental element or 'personality' of society as determined in our analytics." The precinct is distinguished from the corporation, and is the smallest political group, but in Mr. Wright's scheme it is endowed with many of the most important functions of government.

The fifth unit is the nation, which is political on the larger scale; and the sixth unit of society is mankind, or the human race, the aggregate of all nationalities. Under this classification the author discusses a wide range of questions—in fact,

everything that belongs to government, reform, philanthropy, education, social progress, communism, etc. The present volume is the first of a series to be carried out as the leisure or opportunity of the author may allow.

THE PROBLEM OF PROBLEMS, AND ITS VARIOUS SOLUTIONS; or, Atheism, Darwinism, and Theism. By CLARK BRADEN, President of Abingdon College, Illinois. Cincinnati: Chace & Hall. Pp. 480.

IN a note prefixed to this volume, and addressed to reviewers and critics, the author requests these parties to "carefully read the book before they review it." This is only fair, and we undertook to comply with the writer's wish, but failed to get through with it either carefully, hastily, or in any other way. For life is short at the best, and is rapidly shortening, while work multiplies, and but little time is left for reading. Moreover, President Braden's volume is very substantial, and contains a good deal of printed matter on a page, which increases alarmingly after the 342d. Beyond doubt, if the depth of the work is in proportion to its length, it must be valuable. Not having carefully read it, we shall not venture to review it, but we quite agree with the author as to the importance of the discussion; and, as in his title he has sandwiched Darwinism between Theism and Atheism, our readers will infer his point of view to be that of the theologian. The book is a theological onslaught upon the school of thinkers of which Mr. Darwin is now the most conspicuous representative. We gather from the introduction that the author formerly did vigorous service, and probably won his theological spurs, as a fighter of infidels in public debates and written discussions. He considers that this has afforded him a valuable "training" as a champion of religion against the new phase of scientific infidelity, and which enables him to deal very decisively with Darwin, Mill, Huxley, Spencer, Draper, Tyndall, and the like, whom he cuffs and mauls about, in his book, without the slightest mercy. The "Problem of Problems" is obviously a good deal such a work as "Modern Physical Fatalism," which we noticed last month, but is much longer.

AËRIAL NAVIGATION. By the Late CHARLES BLATCHFIELD MANSFIELD, M. A. Edited by his Brother, with a Preface by J. M. LUDLOW. Macmillan & Co. Pp. 513. Price, $5.

THE author of this book, who wrote also "Travels in Paraguay and Brazil," and a "Theory of Salts," is said by Mr. Ludlow, in his preface, to have been a man of great fertility and originality of mind. He says:

"Those who knew him intimately—a now fast-narrowing circle—recollect well how there would come upon him occasionally, after intervals of quiescence, a kind of divine *afflatus*, and for a time his mind would bring forth one device after the other in rapid succession, as those to whom the world restricts the name of poets multiply their works during periods of creative energy. The present volume is the fruit of one of these periods, and the words at the close of the author's preface, 'My object in writing it will be simply to deliver my brain of a burden which came upon it uninvited,' express, I believe, the strictest truth as to his mental experience. . . .

"If it be asked why, after the lapse of a full quarter of a century, an unfinished work by one who is no more on earth is presented to the public, the answer is—1. That the author himself wished to have so presented it when perfect, and that he was one of those whose wishes have a right to be carried out as far as may be practicable. 2. That although the fact that he never completed it might militate against its publication unfinished, yet it does not appear that any publication issued since his death has in any wise taken the place which this volume was meant to occupy. 3. That during the same interval events of high gravity in the world's history have shown that the question of aërial navigation may be one of life and death to a nation. For we have lived to see, what Charles Mansfield did not, France governed through balloons from besieged Paris, and a dictator, who refused to despair of his country, cross the air over the heads of hostile armies."

Mr. Mansfield believed in the practicability of aërial navigation, and that the problem will at length be solved, and the work is a close and searching inquiry into the principles upon which such solution must depend. It will, therefore, be important to the students of aërostation.

The following passage from that witty philosopher, Hans Christian Andersen, when treating of the "ugly duckling," serves as a motto for the volume: "'What next, I wonder?' said the hen. 'You have nothing to do, and so you sit brooding over

such fancies. Lay eggs or pur, and you'll forget them.'

"'But it is so delightful to swim on the water,' said the duck; 'so delightful when it dashes over one's head, and one dives down to the very bottom.'

"'Well, that must be a fine pleasure,' said the hen. 'You are crazy, I think: ask the cat, who is the cleverest man I know, if he would like to swim on the water, and perhaps to dive, to say nothing of myself. Ask our mistress, the old lady, and there is no one in the world cleverer than she is: do you think that she would like to swim on the water, and for the water to dash over her head?'

"'You don't understand me,' said the duck."

TWELVE IDIOMS SPOKEN IN THE SOUTHWEST OF THE UNITED STATES: PUEBLO AND APACHE DIALECTS, TONTO, TONKAWA, DIGGER, UTAH. Vocabularies, published and commented upon by Prof. ALBERT S. GATSCHET. Weimar, 1876. 8vo, pp. 150. (In the German language.) Westermann & Co.

IN this volume a series of vocabularies and phraseology, collected by members of Lieutenant George M. Wheeler's survey-parties, were made the object of a comparative investigation by the author, a resident of New York City, who is already known to the scientific world by various treatises on Indian languages, and on European dialects found in the Alpine valleys. Oscar Loew, chemist of one of Lieutenant Wheeler's parties, collected the main portion of these vocabularies, adopting for them the alphabetical notation recommended by the Smithsonian Institution. To solve the long-standing problem of the primordial habitat of the Aztec tribe, which forms a portion of the far-stretching Nahua race of natives, the author has united all the linguistic information which can at the present time be derived from the study of the Pueblo languages, and has also illustrated the radical affinities of the other language-stocks, which form the object of the publication. In addition to this, the volume contains one of the most exhaustive enumerations of American language-stocks and dialects ever attempted from the genealogical standpoint, embracing North, Central, and South America, and gives a transparent synopsis of the plan of thought and the morphological processes observed in various idioms of the Western Hemisphere. From a separate chapter, the contents of which are novel to science, and of the highest linguistic interest, we become enabled to follow Indian thought and Indian combinatory powers to the very abysses and mysteries of primeval word-formation and word-composition.

A short appendix compares and analyzes numerous terms embodied in the large word-table on pages 27 to 117, and classifies the numeral adjectives according to the various systems of numeration in use all over the divers parts of the globe (binary, quinary, etc.). On the last pages two curious Southern rock-inscriptions are figured and their interpretation attempted.

THE LAND-BIRDS AND GAME-BIRDS OF NEW ENGLAND, WITH DESCRIPTIONS OF THEIR HABITS, AND NOTES. By H. D. MINOT. Salem: Naturalists' Agency, 1876. Pp. 350. Price, $3.

THIS book is likely to attract the attention of ornithologists on account of both its good and bad qualities. It is restricted in its scope to New England, and intended chiefly to report what the author has himself observed in the neighborhood of Boston, but the biographies are extended by copious quotations. Mr. Minot seems to regard the subject from the standpoint of an oölogist, and makes the breeding habits of birds the most prominent feature of his history. The long introduction is especially addressed to egg-collectors or students, and contains minute information upon forming oölogical cabinets. This portion of the book should have been revised by the author, and cut down at least one-third. As to the long appendix, embracing keys by which to identify the eggs of the birds, and the birds themselves mentioned in the volume, it is practically useless; while the construction of the two indexes is foolish. This misfortune arises from the method of the book, which—its character and object considered—is altogether bad. The arrangement of his subject-matter, under various signs and paragraph-marks, is only an obstruction, and we are sure the really great value of the work, as a whole, would

be much more striking if this complicated, cross-reference catalogue arrangement had been dispensed with.

Although the information conveyed is local, the accounts of the habits of the birds contain many new and valuable facts, stated in a way to inspire confidence in the reader. Mr. Minot's style, though often somewhat crude, and showing marked defects, is pleasant and strong. He has paid particular attention to the notes and songs of birds, and describes their music felicitously. Evidently he has had a sharp eye upon them everywhere, and under all sorts of circumstances, for his delineations abound in minute touches, which show close observation.

THE ANDES AND THE AMAZON; OR, ACROSS THE CONTINENT OF SOUTH AMERICA. By JAMES ORTON, A. M. Third edition, revised and enlarged, containing Notes of a Second Journey across the Continent from Pará to Lima and Lake Titicaca. With two Maps and numerous Illustrations. New York: Harper & Brothers, 1876. Price, $3.

IN popular interest and in general scientific value this volume by Prof. Orton will occupy a favorable position among the many excellent books of South American travel that have appeared since the great work of Darwin in 1835, and to whom the volume before us is fittingly dedicated.

The account of the first journey, made in 1867, was published soon after; and was favorably received. The route on that occasion was from Guayaquil to Pará, at the mouth of the Amazon, by way of Quito.

The second journey was made in 1873, and commenced where the first one terminated.

By aid of two excellent maps, the route of the traveler can be followed from Pará up the Amazon, thence through forests, and over horrible roads upon the eastern slope of the Andes, to the great plateau and city of Cajamárca, "the most beautiful plain in all the Andes." The city is 9,400 feet above the Pacific. In it are the remains of Atahuallpa's palace and other memorials of the struggles of the Peruvians with the Spaniards.

"Two days from Cajamárca, the party shouted for joy at the sight and sound of a locomotive," a sign that their hardships were over. The Andes of Peru are being traversed by roads grander than those of the Aztecs.

Having arrived at the Pacific coast, a half-hour's ride by rail took the travelers to the city of Lima. Arriving at Mollendo, a new village, "with the ocean on one side and a vast desert on the other," Prof. Orton took the train for Lake Titicaca, a distance of 325 miles. He was the first passenger over the newly-finished road to the lake from the Pacific. The route is over deserts and apparent solitudes, on which look down some of the snowy giants of the Andes 18,000 feet high. At 107 miles the train stopped at Arequipa, a city in a valley of green verdure; and, finally, at Puno, an Indian village, 12,547 feet above the ocean. Before reaching it the waters of Lake Titicaca were seen.

The highest point on the route was 14,660 feet, where snow lay on the hills, and where there was no sound of life. "So profound was the stillness that the buzzing of an insect would have been painful."

"I gazed," says the author, "rapt in thought, upon the lake, brimful of history. Its surface, at a height of 12,493 feet, lies level with the tops of lofty mountains, and it has an area of 2,500 square miles."

Everywhere around it are monuments of a civilization which has passed away.

Of the railroads of Peru, the Oroya, which was being built, will attain at its greatest elevation a height of 15,645 feet above the level of the sea.

The geology and natural history of the Amazon region and the Andes, their resources and inhabitants, make several chapters of great interest. Besides two maps, the volume contains 80 illustrations.

SCIENCE LECTURES AT SOUTH KENSINGTON: 1. "Photography," by Captain ABNEY. 2. "Sound and Music," by Dr. STONE. 3. "Kinematic Models," by Prof. KENNEDY. MANCHESTER SCIENCE LECTURES FOR THE PEOPLE: 1. "What the Earth is composed of," by Prof. ROSCOE. Macmillan & Co.

THESE are all excellent addresses by able men, and as popular as the nature of the subjects will allow. They are illustrated, and on good paper, and the publishers furnish them at 20 cents apiece.

PRACTICAL COOKERY AND DINNER-GIVING. A Treatise containing Practical Instructions in Cooking; in the Combination and serving of Dishes; and in the Fashionable Modes of entertaining, at Breakfast, Lunch, and Dinner. Illustrated. By Mrs. MARY F. HENDERSON. Harper & Brothers. Pp. 376. Price, $1.50.

NOTWITHSTANDING the multitude of books, good, bad, and indifferent, that treat of cooking and eating in all their aspects, the subject is yet far enough from being exhausted—the plenitude of its literature serving chiefly to convince us of the importance of the subject. But there is evidently an awakening in the culinary world, and a growing sense that, although it may have rained cook-books for a century, the work of reforming the kitchen and dining-room, and bringing them into some rational method of management, remains still to be accomplished. The dissatisfaction with bad cooking and barbarous eating is steadily spreading, cooking-schools are multiplying, and many are asking anxiously what can be done to amend our imperfect and evil ways in the preparation and serving of food.

Mrs. Henderson has therefore chosen a fitting time to put forth the results of her study, observation, and experience, on these important matters, and her volume, we think, will be widely welcomed and appreciated, as an excellent contribution to the literature of domestic economy, at the present time. It is comprehensive and practical, and meets the general wants of families in a satisfactory way. It contains much information in regard to culinary implements, processes of cooking, and the methodical operations of the kitchen, which if made available will be certain in most cases to improve that branch of the domestic establishment. It is the merit of Mrs. Henderson's book that it is something more than a compilation; it has grown out of her own practical interest in kitchen-work, much observation and correspondence, and an enthusiasm for housekeeping which ought to be more frequent among ladies. She gives an excellent array of selected receipts, many tested by herself, and others by competent friends, while the choice seems to have been made with discrimination, such only being offered as have "stood the test of time and experience."

An important portion of Mrs. Henderson's book, and which will meet a want in many families, is the prominent attention she gives to the art of serving meals. She says, in her preface: "Care has been taken to show how it is possible with moderate means to keep a hospitable table, leaving each reader for herself to consider the manifold advantages of making home, so far as good living is concerned, comfortable and happy." Mrs. Henderson expatiates on "the fashionable modes of entertaining at breakfast, luncheon, and dinner," but insists that, in this case, fashion is not the equivalent of folly. There is a general impression that the genteel mode of doing the thing is expensive and extravagant. This would, of course, be so in many cases where ostentation is the object, but according to Mrs. Henderson it is not necessarily so. "Fortunately," she says, "the fashionable mode is the one calculated to give the least anxiety and trouble to a hostess." People will no doubt continue to dispense breakfasts, lunches, and dinners, on a scale proportioned to their means, but the author of this book aims to point out how a family can live well and in good style, and at the same time with reasonable economy. The book is written in a simple, direct, and common-sense manner, that leaves nothing wanting in the way of clearness.

A COURSE OF PRACTICAL INSTRUCTION IN ELEMENTARY BIOLOGY. By T. H. HUXLEY, LL. D., etc., assisted by H. N. MARTIN, B. A., etc. Macmillan & Co., 1876. Second edition, revised.

PROF. HUXLEY has made himself remarkable among the leading scientific lights of the day, quite as much by the ease and assiduity with which he has simplified and expounded to the unlearned the mysteries of natural history as by the mental acumen and power which have enabled him to discover so many of those mysteries. He is known better, perhaps, in England to-day as a teacher than as an investigator; hence it is not surprising that he has undertaken to sketch out and supervise the little book, costing only two dollars, of elementary biological lessons, which has been written by Prof. Martin, his former assistant and now Professor of Zoölogy at Hopkins University in Baltimore. It has grown out of Prof. Huxley's own experience as a teacher, and hence

is a thoroughly practical guide for progressive laboratory-practice, approaching the study through morphology and botany, which the professor considers the only safe road to a sound knowledge. "The study of living bodies," the author tells us, "is really our discipline, which is divided into zoölogy and botany simply as a matter of convenience, and the scientific zoölogist should no more be ignorant of the fundamental phenomena of vegetable life than the scientific botanist of those of animal existence."

The object of the book being to make it a laboratory-guide, a number of common and readily-obtainable plants and animals have been selected in such a manner as to exemplify the leading modifications of structure which are met with in the vegetable and animal worlds. A brief description of each is given; and the description is followed by such detailed instructions as will enable the student to know, of his own knowledge, the chief facts mentioned in the account of the animal or plant. "The terms used in biology will thus be represented by clear and definite images of the things to which they apply; a comprehensive and yet not vague conception of the phenomena of life will be obtained; and a firm foundation upon which to build up special knowledge will be laid." Beginning with yeast, gradual advance is made to successive studies of protococcus, proteus animalcule, colorless blood-corpuscles, bacteria, moulds, stoneworts, ferns, the bean-plant, the bell animalcule, fresh-water polyps (*hydra*, etc.), the fresh-water mussel, the crawfish and lobster, and lastly the frog. A sketch of the habitat and general characters, the development, mode of growth and microscopic structure, anatomy, modes of movement, etc., etc., of each is given, followed by a schedule of laboratory-work, directing the student, with the aid of excellent figures, to the recognition of all the parts of the animal or plant studied, not only in their shape and position, but in their relation to other parts, their functions and their development. The chief labor in drawing up these instructions has fallen upon Dr. Martin; but for the general plan used, and the descriptions of the several plants and animals, Prof. Huxley holds himself responsible. The result is a book of the greatest value for beginners in the study of biology; supplement it by Rolleston's "Forms of Animal Life," and we have a whole library. Students who wish to "know of their own knowledge" can certainly find no better guide than this.

LECTURES ON SOME RECENT ADVANCES IN PHYSICAL SCIENCE. With a Special Lecture on "Force." By G. P. TAIT, M. A. Second edition, revised. Macmillan & Co. Pp. 363. Price, $2.50.

OF this new edition we can only repeat what we said at the appearance of the first, that it will be found an instructive discussion of modern dynamical problems, well worth the perusal of all who are interested in this class of questions. The pugnacious temper of the author, or rather perhaps the facility with which he gets into hot water with other scientific men, is illustrated by the preface to the new edition, which is chiefly devoted to his quarrel with the German physicist, Prof. Clausius. In his additional lecture on "Force" he discusses the different meanings that are given to the term, and the confusion that results. His conclusion is, that "there is probably no such *thing* as force at all! that it is in fact merely a convenient expression for a certain 'rate.'" We suspect that more work will have to be done here before the matter will be finally cleared up.

ESSAYS IN LITERARY CRITICISM. By RICHARD HOLT HUTTON. Philadelphia: Coates & Co. Pp. 355. Price, $1.50.

IT is one of the great defects in literary criticism that a person who admires certain books or authors cannot detect their faults, and that he who is prejudiced against them is unable to see their excellences. Mr. Hutton is, in a remarkable degree, free from this deficiency, and points out failings in his favorite authors which even a hostile critic might not have observed. His great power is in being able to get at the fundamental thoughts of the men whom he criticises. He is apparently more concerned in expressing with careful minuteness all his ideas on a given subject than in elaborating them into an elegant style. The essays which make up this volume are on "Goethe," "Nathaniel Hawthorne," "Arthur Hugh Clough," "Wordsworth," "George Eliot," and "Matthew Arnold."

THE LIFE-HISTORY OF OUR PLANET. By WILLIAM D. GUNNING. Illustrated by MARY GUNNING. Chicago: W. B. Keen, Cooke & Co. Pp. 368. Price, $2.

To the obvious criticism that so large a subject as "The Life-History of Our Planet" cannot very well be compressed within the limits of a handy volume like the present, it may be fairly replied that an outline of such a history, giving its leading features and more impressive aspects, is altogether a practicable thing. Prof. Gunning has shown this in the preparation of the volume before us, which certainly presents the leading historic aspects of terrestrial life in a manner that is highly instructive. The book is a successful attempt to popularize a great branch of science without sacrificing or cheapening it. Although the author deals with many new facts which are usually wrapped in an obscure terminology, he yet presents them in such a plain, familiar, direct, common-sense manner as to be understood by all readers who have the slightest interest in the subject. Well experienced in public teaching, he neither overshoots the average capacity nor wearies it by dwelling too long upon the minutiæ of his topics. He, moreover, gains much in compression of statement by giving prominent attention to the general views and truths of his subject, rather than to its interminable particulars. His mode of exposition is indicated in the following prefatory passage: "Facts do not enlarge the mind unless they are fertilized by principles. Our aim in the preparation of this volume has been to conduct the reader through methods to results. The leading types of life which have possessed the earth from age to age, he will find described and delineated. He will find the more significant types reconstructed, part by part, with so little of the phraseology of comparative anatomy that his mind, it is hoped, will traverse the methods and make them his own." The aim here proposed has been well attained, and, by treating his subject in the light of the great principles of unity, correlation, progressive unfolding, and interconnection with the course of physical Nature, the author has invested the great historical problem of the earth's past life with unusual interest and attractiveness.

We should like to quote copiously from "The Life-History of Our Planet," but have not room to do so. The following passage is representative, and illustrates the writer's clear and pointed way of picturing phenomena before the minds of his readers:

"In 1818 Traill dissected one of the higher apes, and found in the region of the thigh a muscle which he thought had no representative in man. He named it the *scansorius*, or 'climbing' muscle. Late dissections have shown Traill to have been in error. Its homologue in man is found to be the little muscle called *gluteus minimus*. What is the meaning of this little useless muscle in man, unless it is the atrophied descendant of a real scansorius? In that man-like ape, the orang, Dr. Barnard, of Cornell, has found a muscle whose homologue has never been found in man. In the orang it occurs as a vestige. It has almost faded out. It occurs in the lower apes and in the half-apes, but always as a vestige, having no functional value. It appears again in the opossum, but no longer as a vestige. Thus, a muscle which is obsolete in man, almost obsolete in the higher apes, less aborted in the lower apes, still less aborted in the half-apes, is found in the opossum with its functional value."

The first chapter of the book is devoted to what may be called the preliminary physics and geology of the subject. The second, third, and fourth, treat of the rise and evolution of organic types, and the fifth is devoted to the question of glaciers and the part they have played in the history of the earth's surface. This is an excellent chapter, and gives a very clear account of that most difficult matter for popular explanation—the relation of the precession of the equinoxes, and the secular variations of the earth's orbit to the glacial periods. The development of animals, the appearance upon earth of man, his antiquity and migrations, and the origin and derivation of races, occupy the remaining four chapters of the work, which may be regarded as a kind of preliminary text-book of philosophical biology. It is neatly and fully illustrated, and deserves to have a wide circulation.

THE AMERICAN LIBRARY JOURNAL. (Monthly.) Managing Editor, MELVIL DEWEY. New York: F. Leypoldt. Yearly subscription, $5.

MORE than usual interest has been taken in the public libraries during the last year. The recent conference at Philadelphia, and the Report of the Educational Bureau at Washington, have now been supplemented by the *Library Journal*. Its plan is to cover the entire field of library and biblio-

graphical interests, to answer, by leading articles, communications, notes, etc., all the questions which come up in the experience of librarians, and to form "an inspiration that will keep them up to their profession."

The coöperative system ought to work with as much benefit in libraries as it does in other cases; and if, by mutual assistance, their condition can be improved, the good influence will extend to the people who use them. It was for the purpose of helping on in this good work that the *Library Journal* was undertaken. There is a large band of associate editors, representing the leading libraries of the country, who should be able to make this periodical valuable to all interested in the subject.

REPORT OF THE EXPLORING EXPEDITION FROM SANTA FÉ TO THE JUNCTION OF THE GRAND AND GREEN RIVERS IN 1859, UNDER THE COMMAND OF CAPTAIN J. N. MACOMB; WITH GEOLOGICAL REPORT BY PROF. J. S. NEWBERRY. Washington: Government Printing-Office. Pp. 152.

THE larger part of this work is occupied with Prof. Newberry's geological report. This was originally written and prepared for publication in 1860, but did not appear on account of the rebellion. Accompanying it is a map of the region, with eleven water-color sketches, showing the characteristic scenery, and eleven drawings, three of scenery and eight of fossils. The report concludes with descriptions of the cretaceous, carboniferous, and triassic fossils collected on the expedition.

FOREST-CULTURE AND EUCALYPTUS-TREES. By ELLWOOD COOPER. San Francisco: Cubery & Co. Pp. 238. Price, $1.50.

A LECTURE by the author on "Forest-Culture and Australian Gum-Trees" occupies the first part of this little book. To it are appended four essays by Frederick von Müller, of Austria, discussing various subjects relating to forest-culture, the desirableness of planting trees, etc. The cultivation of trees is a matter of considerable importance, and this work is intended to impress it upon the public attention.

The "Fifth Annual Catalogue of the Santa Barbara College" takes up the last thirty pages of the book.

VACCINATION AS A PREVENTIVE OF SMALL-POX. By W. C. CHAPMAN, M. D. Toledo: Brown & Faunce. Pp. 91.

THERE is found to be an inverse ratio between vaccination and small-pox, and the average amount of deaths from small-pox has been only two in a thousand in those countries where vaccination has been rendered compulsory. Its importance is now universally admitted, though it is not so generally acted upon, and for this reason any fresh reminders cannot fail to be beneficial. While advancing nothing absolutely new, Dr. Chapman presents the existing knowledge in a manner which affords a full understanding of the subject. After giving a history of its earliest application and development, he discusses the following questions: "Does vaccination protect the system from contagion of small-pox? Why does the protective power of vaccination become so impaired as to render revaccination advisable? What causes have prejudiced the public against the operation of vaccination? What measures should be instituted to enforce a due appreciation of the benefits of vaccination?"

RULES FOR A PRINTED DICTIONARY CATALOGUE. By CHARLES A. CUTTER, Librarian of the Boston Athenæum. Washington: Government Printing-Office. Pp. 89.

THIS pamphlet forms the second part of the United States Government report on the public libraries. In many of our smaller cities and towns the value of the libraries is greatly impaired, since there is no direct way of discovering their contents, or of being able to find a book on a given subject. As the libraries enlarge and outgrow their catalogues, these difficulties increase. Mr. Cutter goes into the minutest details of classification in this essay, laying down 203 rules which he expands and illustrates. The work is, perhaps, a little too thorough to be altogether practical in the hands of many librarians. If the directions were not quite so numerous, and some of the details had been suppressed, it might have been more effective. A librarian will, however, be better able to utilize the books under his charge if he make himself familiar with the rules given by Mr. Cutter.

THE POPULAR HEALTH ALMANAC, for 1877. Edited by FREDERICK HOFFMANN. New York: E. Steiger. Pp. 40. Price, 10 cents.

THIS is a valuable and most useful compilation of applied health-knowledge, such as should be found in every family. The first number was issued last year, and was so well appreciated that it is followed by another this year, and we hope the series will be continued. One of its most important features is to expose the traffic in patent medicines, and, to show their fraud and worthlessness, the chemical composition of many popular nostrums is given. We fully agree with the following estimate of this almanac, given by Dr. Elisha Harris: "Accept my thanks and very hearty congratulations for the admirable little manual which you have justly entitled 'Popular Health Almanac.' It certainly is the most acceptable and well-arranged compilation for public instruction on sanitary matters I ever saw; indeed, it is far more and better than a compilation, so happily has Dr. Hoffmann studied and crystallized the limits and substance of sanitary knowledge in the modest and beautiful little Health Mentor which, in all particulars, has been so wonderfully well designed and executed that thousands of families will sincerely thank its editor and publisher."

THE FIRST FONAKIGRAFIK TEACHER: A Guide to a Practical Acquaintance with the Literary Style of the Art of Phonachygraphy. An Improved Substitute for Long-Hand Script, etc., etc. Amherst, Mass., U. S. A.: John Brown Smith, Author and Publisher. Pp. 24. Price, 25 cents.

FOR such a humble little print as this the pretensions are very lofty, as it aims to make a revolution in the future modes of printing and writing. Following out the idea that "to save time is to lengthen life," the author remarks: "The saving of time in acquiring an education would be almost one-half if fonakigrafi (?) was exclusively used for both print and script, thus doing away with the absurdity of having half a dozen different alphabets for print and script as in use at present." Mr. Smith will, however, probably have to rack his brain again before he can invent a system that will completely set aside Pitman and his imitators or 'improvers. Undoubtedly, improvements will be made in the art of short-hand writing, but what direction they will take is not determined by this tract.

MATTER AND FORCE: A Course of Lectures on Physics. By J. K. MACOMBER. Ames, Iowa: Agricultural Steam-print. Pp. 95.

DURING the past few years Prof. Macomber has delivered the contents of this book, as a series of nine lectures, to his classes in Natural Philosophy. They are adapted to persons who have completed the elementary study of physics, and include the more recent views respecting matter and force. He treats, among other subjects, of "Potential Energy," and the "Correlation of Vital and Physical Forces," and gives the modern speculations in regard to the "Sun as a Centre of Force," with its relation to the existence of the solar system.

THE SURFACE-DRAINAGE OF THE METROPOLITAN DISTRICT. By C. W. FOLSOM, C. E., of Cambridge. Boston: Wright & Potter, State Printers.

MR. FOLSOM discussed this subject in the "Seventh Report of the Massachusetts State Board of Health," but its importance has warranted its separate publication. He does not attempt to treat surface-drainage exhaustively, but rather suggests its necessity, and the diseases to which its neglect gives rise, pointing out the particular districts in the neighborhood of Boston which are in greatest need of treatment.

THE ESSENTIAL PIETY OF MODERN SCIENCE. A Sermon. By JOHN W. CHADWICK, Minister of the Second Unitarian Society in Brooklyn. For sale by Charles P. Somerby, 139 Eighth Street, N. Y.

MR. CHADWICK read this sermon or address before the National Conference of Unitarian and other Christian Churches, held at Saratoga in September. He shows a decided liking for modern scientific tendencies, and believes that there is that in scientific thought which directly fosters all those sentiments which are the life-blood of religion.

PUBLICATIONS RECEIVED.

Applications of Physical Forces. By Amédée Guillemin. Edited by J. N. Lockyer. New York: Macmillan. Pp. 770; with colored Plates and Illustrations. Price, $12.50.

Notes on Life Insurance. By Gustavus W. Smith. New York: Van Nostrand. Pp. 204. Price, $2.

Report of the Commissioner of Education. Washington: Government Printing-Office. Pp. 1,189.

National Quarterly Review. New York, 658 Broadway. Pp. 192. $5 a year.

European Surveys. By Major C. B. Comstock, of the Engineers. Washington: Government Printing-Office. Pp. 101.

Transactions of the Asiatic Society of Japan (1876). Yokohama: *Japan Mail* office. Pp. 178.

Celestial Dynamics. By J. W. Hanna. The author, Mount Vernon, Iowa. Pp. 32. Price, 35 cents.

National History of Illinois. Bulletin No. 1. With Plates. Bloomington: Pantograph Printing-House. Pp. 76.

Survey of the Northern and Northwestern Lakes. Major C. B. Comstock in charge. With Plates. Washington: Government Printing-Office. Pp. 84.

Catalogue of Swarthmore College, Pennsylvania. Pp. 55.

Effects of Alcoholic Poison. By J. H. Kellogg, M. D. Battle Creek, Michigan: *Health Reformer* print. Pp. 125.

The Mathematician. Royal Cooper, editor. Vol. I., No. 1. Pp. 16. Washington: *National Republican* print. $1.50 a year.

Giant Birds of New Zealand. By J. C. Russell. From *American Naturalist.* Pp. 11.

Biographical Notice of A. R. Marvine. By J. W. Powell. From the Bulletin of the Washington Philosophical Society. Pp. 8.

American Annals of the Deaf and Dumb. E. A. Fay, editor. Vol. XXII., No. 1. Pp. 64. Washington: Gibson Brothers print.

Climato-therapy of Consumption. By Dr. S. E. Chaillé. From the *New Orleans Medical and Surgical Journal.* Pp. 12.

Corundum. By C. W. Jenks. Boston: J. Wilson & Son, printers. Pp. 17.

Ueber die Darstellung und Eigenschaften des Trijodresorcins. Von Arthur Michael und Thomas H. Norton. Berlin: F. Dümmler. Pp. 2.

Intimidation and the Number of White and Colored Voters in Louisiana. By S. E. Chaillé, M. D. New Orleans *Picayune* print. Pp. 36.

POPULAR MISCELLANY.

Antarctic Icebergs. — Sir C. Wyville Thomson, in a lecture reported in *Nature* for November 30th and December 7th, presents facts of interest obtained during the cruise of the Challenger, concerning the antarctic regions visited.

The expedition met with its first ice five days' sail southward of the desolate, rocky group known as the Heard Islands. In a short time the ship was in the midst of bergs of exquisite beauty of both form and color.

The most southerly point reached was latitude 66° 40′ south, longitude 78° 22′ east, when they were exactly 1,400 miles from the south pole. The icebergs, some of them of immense size, were tabular in form, "the surface being level, and parallel with the surface of the sea . . . a cliff, on an average 200 feet high, bounding the berg. The cliffs were marked with delicately pale blue lines a foot apart near the top, closer together near the bottom; the intervening bands were white, probably from containing some air. . . . The stratifications of the bergs being originally horizontal, they were believed to be blocks riven from the edge of the great antarctic ice-sheet."

A further conclusion was that the stratification was due to successive accumulations of snow upon a nearly level surface. There was no evidence that the ice had passed over uneven surfaces, nor was there upon the bergs any trace of *débris*, such as might fall from elevated cliffs. The snow

upon the surface of the bergs was of dazzling whiteness, but, in places, faint discolorations, due not to earthy matter, but to the presence of birds, were observed. Prof. Thomson concludes that the ice from which the bergs were broken was found upon low, level land that was surrounded by shallow water.

Although no *débris* were seen upon the bergs, it is quite certain that large quantities of them were held in their under portions, whence they dropped into the sea, as such deposits were continually brought up by the dredge.

Prof. Thomson suggests that the increase of glaciers in thickness may be limited by melting at their under surface from pressure of the mass. A column of ice, 1,400 feet high, he estimates to lie upon the ground with a pressure of nearly a quarter of a ton to each square inch of surface, nor does he find reason to doubt that the temperature of the earth's surface beneath the glacier is about 32°. He cites the fact that from beneath glaciers in Greenland muddy streams are continually discharged. It is possible, therefore, that the antarctic glaciers, covering vast level tracts, are prevented from accumulating to a thickness much exceeding 1,400 feet, by waste in the bottom portions, where constant melting and regelation are going on.

On the chart of the American explorer, Lieutenant Wilkes, a position is given for what he called Termination Land. On closely approaching the spot, no land was found, and Prof. Thomson was "forced to the conclusion that Lieutenant Wilkes was in error."

The interesting fact was revealed by soundings that a layer of water 300 fathoms below the surface was warmer by several degrees than water at the surface, and it was ascertained that the heat increased northward. Hence it was concluded that the source of the warm water was northward, and that it may have been deflected by the southward projection of continental lands, turning southward currents which have their origin in the "great drift-current which sweeps round the globe."

Animals and Steam-Engines.—A writer in *Dingler's Polytechnisches Journal*, in noting the behavior of different animals toward the steam-engine, remarks upon the dexterity with which dogs run about among the wheels of a departing railway-train without suffering the least injury, whereas a host of railway workmen annually lose their lives. On the other hand, the ox, a proverbially stupid animal, continues standing composedly on the rails, having no idea of the danger which threatens him, and is run over. Many kinds of birds seem to have a peculiar delight in the steam-engine. It has often happened that larks have built their nests and reared their young under the switches of a much-traveled railway. In engine-houses the swallow is a frequent guest. In a certain mill, where a noisy, three hundred horse-power engine works night and day, two pairs of swallows have built their nests for years, and rear their young there regularly. A case of almost incredible trustfulness on the part of swallows occurred in the early part of last year, when a pair of these birds built in the paddle-box of a steamer, and regularly made the journeys from Pesth to Semlin. The author concludes with this caustic remark: "I have never yet found any animal at home in the boiler-house. Even the dog steers clear of boilers. It is almost as if the lower animals knew what an amount of stupidity and folly appears in our construction of boilers."

Prof. Dana on Cephalization.—The fifth of Prof. Dana's interesting papers on "Cephalization" is published in the *American Journal of Science and Arts* for October. The author's thesis here is that cephalization is a fundamental principle in the development of the system of animal life. As the animal grade rises, there is a compacting of structure in both the fore and hinder parts of the body. Of mammals the lowest forms are those having their locomotive functions in the posterior parts of the body, while in the higher forms the forces or force-organs are more and more forward in the structure. There are large size and strength behind in low forms, but a compacting of these and a better head in the higher.

The head becomes more and more the centre of nervous energy or force as development goes on, and this is to be seen in the specific forms of Nature. "Here form,"

says the author, "is with some limitations an expression of force."

Cephalization is shown both in embryonic development and in the progress of life in geological history. The law is further illustrated by the discoveries of Prof. Marsh, from which it appears that the brains of the great mammals of the early Tertiary were very much smaller than those of allied species of recent time. Thus the brain of the dinoceras, of the Eocene, was not more than one-eighth the size of that of the modern rhinoceros, showing an immense development of the brain, while the bulk of the animals has decreased. We have also a development of those features of both form and capacity which are characteristic of brain-power.

The increase of the brain and nervous system may arise, the author suggests, from the fact that this part of the structure comes in contact with outside and inside Nature, and is the means by which the animal has communication with the outer and inner world, and with its own inner workings and appetites. This constant and energetic use of the brain may have given to it its wonderful growth and strength since Eocene times.

But brain-progress could not have taken place without structural progress, and structural changes have been determined by it. Brain-force reacts upon and modifies both form and structure.

It is not claimed by the author that the theory of cephalization accounts for all the types of structure found in the animal world, but only that whatever these types may have been in course of development they were in general subordination to the principle of cephalization. "The origin of the grander types of structure," writes Prof. Dana, "must be connected with the profoundest of molecular laws; and how connected man may never know. These views may hold, whatever be the true method of evolution. The method by repeated creations should be subordinated, as much as any other, to molecular law and all laws of growth; for molecular law is the profoundest expression of the Divine will. But the present state of science favors the view of progress through the derivation of species from species, with few occasions for Divine intervention. If, then, there has been derivation of species from species, we may believe that all actual struggles and rivalries among animals leading to 'survival of the fittest' must tend, as in man, to progress in cephalization and dependent structural changes."

On the Origin of Prairies.—Having shown, in an article which we noticed in the December number of the MONTHLY, the untenableness of the current hypotheses with regard to the origin of prairies, Prof. J. D. Whitney now presents, in the *American Naturalist*, a theory of his own. He finds, as the result of a great number of observations made over all the prairie States, that almost without exception absence of forests is connected with extreme fineness of soil, and that this fine material usually occurs in heavy deposits. "No person," he remarks, "can have traveled through Southern Wisconsin, Illinois, Iowa, or Missouri, without having had everywhere occasion to observe that the prairie-soil is exceedingly fine and deep; there are whole counties in Iowa in which not a single pebble can be found." The distribution of the timbered and prairie tracts in Wisconsin affords a good test of the correctness of the author's hypothesis. In the northern part of the State is a region of dense forest, though this is not a region of large precipitation. It is, however, heavily covered with coarse detrital materials, plentifully distributed from the headquarters of the drift on Lake Superior. The rocks underlying the drift-deposits are crystalline, belonging to the Azoic series, and the surface is rough and broken, being intersected with low ridges and knobs of granite and trap. South of this is a large area, occupying the central portion of the State, and extending as far as the Wisconsin River, almost exclusively occupied by a very pure siliceous sandstone, which is wrapped about the Azoic region, extending in a northeasterly direction to the Menomonee River, and northwest to the falls of the St. Croix. This great sandstone-covered area is the pine-district of the State, while south of the Wisconsin is the region of oak-openings and prairies. When we reach these treeless tracts we have got entirely beyond the drift-covered area, and are upon a soil made up of the insoluble residuum left from

the disintegration of several feet in thickness of limestone and dolomite, which have been dissolved out and carried away by the rain.

Albertite.—This substance, now largely consumed as an enricher of illuminating gas, is thus described in a recent number of the *Iron Age:*

"A very curious mineral known as albertite is found in New Brunswick. It occurs in connection with calcareo-bituminous shales, and has been by some regarded as true coal, by others as a variety of jet, and by others again as more nearly related to asphaltum. The true nature of the mineral was made the basis of a lawsuit in Scotland a few years ago, in which the amount involved was something more than a million pounds sterling, as the decision settled the question of the liability to pay a royalty. It resembles asphaltum very closely, being very black, brittle, and lustrous, and, like asphaltum, is destitute of structure, but differs from it in fusibility and in its relation to various solvents. It differs from true coal in being of one quality throughout, in containing no traces of vegetable tissues, and in its mode of occurrence as a vein and not as a bed. The vein occupies an irregular and nearly vertical fissure, and varies from one inch to 17 feet in thickness. It has been mined to the depth of 1,162 feet. The accompanying shales are abundantly filled with the remains of fossil fishes, and it is not improbable that from these, in part at least, the mineral was derived, existing at first in a fluid or semi-fluid state. Vegetable remains are almost entirely wanting in the shales. During twelve years since the discovery there have been shipped 154,800 tons of albertite, chiefly to the United States, where it has been used for the manufacture of oil, and for the admixture with bituminous coal in the manufacture of illuminating gas. It is admirably adapted for either of these purposes, yielding 100 gallons of crude oil, or 14,500 cubic feet of gas of superior illuminating power per ton."

Singular Feeding Habits of Wood-Ants.—Mr. McCook, of the Academy of Natural Sciences of Philadelphia, has published in the "Proceedings" of that body some highly-interesting observations on the habits of *Formica rufa*, from which it appears that these ants have in their separate communities regular provision made whereby the workers are fed without having to quit the scene of their labors. The foragers of a community, as they come down the tree-paths, their abdomens swollen with honey-dew—in which condition they are called by the author *repletes*—are arrested near the foot by workers from the hill seeking food. The *replete* rears upon her hind-legs, and places her mouth to the mouth of the hungry worker, or "pensioner," as the author calls him, who assumes the same posture. Often two, sometimes three pensioners are thus fed at once by one *replete*. The latter commonly yields the honey-dew complacently, but sometimes she is seized and arrested by the pensioner, occasionally with great vigor. The author described a number of experiments leading to the conclusion that there was complete amity between the ants of a district embracing some 1,600 hills and countless millions of creatures. Insects from hills widely separated always fraternized completely when transferred. It was found, however, that ants immersed in water, when replaced upon the hills, are invariably attacked as enemies; the assailants being immersed were themselves in turn assaulted. Experiments indicate that the bath temporarily destroys the peculiar odor or other property by which the insects recognize their fellows.

How Meteorites were regarded in Olden Times.—There was a noteworthy fall of meteorites in Berkshire, England, in the year 1628, and devout persons with one accord seem to have looked on the phenomenon as a special act of Divine Providence. The meteorites are "the arrows of God's indignation," and he is entreated "to shoote them some other way, upon the bosomes of those that would confound his Gospell." One Mistress Green had the courage to order one of these heaven-sent "thunder-stones" to be dug out of the ground, and a chronicler of the time gives a description of it. The chronicler himself had little sympathy with the curiosity of Mrs. Green, for he warns his readers against being "so daring as to pry into the closet of God's determinations. His workes are full of wonders, and *not to be examined.*" A letter written by an eye-witness of this fall of meteorites well illustrates the devout credulity of the time. It opens with the following passage: "The cause of my writing to you at this time is by reason of an accident that the Lord sent among us. I have heard of the Lord by the hearing of the ear, as the prophet speaketh, but now mine eyes hath seen him. You

will marvel that I write thus, for no man hath seen God at any time, yet in his works we see him daily, *but now after a more special manner.*" Then, after giving a clear account of the whole occurrence, the writer concludes with an exhortation to unbelievers: "Now let the atheist stand amazed at this work of the Lord." In certain districts of Berkshire there is still a tradition of the fall of these meteorites, and old people speak of it as such an event as to have created a belief at the time that "the world was coming to an end."

Education in the Public Schools of Massachusetts.—Mr. Wendell Phillips recently delivered an address on the subject of education, in which occurred the following remarks upon the value of the intellectual training a girl receives in the public schools of Massachusetts: "The public schools teach her arithmetic, philosophy, trigonometry, geometry, music, botany, and history, and all that class of knowledge. Seven out of ten of them, remember, are to earn their bread by the labor of their hands. Well, at fifteen, we give that child back to her parents utterly unfitted for any kind of work that is worth a morsel of bread. If the pupil could only read the ordinary newspaper to three auditors it would be something, but this the scholar so educated, so produced, cannot do. I repeat it: four-fifths of the girls you present to society at fifteen cannot read a page intelligibly." But the current system of school-education is faulty and defective no less with regard to boys than with regard to girls, for, as Mr. Phillips further observes, "we produce only the superficial result of the culture we strive for. Now, I claim that this kind of education injures the boy or girl in at least three ways: first, they are able, only by forgetting what they have learned and beginning again, to earn their day's bread; in the second place, it is earned reluctantly; third, there is no ambition for perfection aroused. It seems to be a fact, which many of the public educators of to-day overlook, that seven-tenths of the people born into this world earn their living on matter and not on mind. Now, friends, I protest against this whole system of common schools in Massachusetts. It lacks the first element of preparation for life. We take the young girl or the young boy whose parents are able to lift them into an intellectual profession; we keep them until they are eighteen years old in the high schools; we teach them the sciences; they go to the academy or the college to pursue some course of preparation for their presumed course through life. Why not keep them a little longer and give them other than intellectual training for the business of life?"

Influence of Color of Soil on Potatoes.—Having observed that potatoes grown in dark-colored soil are less subject to disease than those grown in soil of lighter color, Mr. J. B. Hannay, member of the Edinburgh Royal Society, conjectured that the difference must be due to the greater absorption of heat by the darker soil. He accordingly made the following experiment: A piece of ground, consisting of a kind of blue till, was divided into two parts, both being planted with potatoes in the ordinary way. One of the parts was then covered with soot, which had been carefully washed till no soluble matter remained in it; the other part was left as planted. The potatoes in the soot-covered portion sprouted first, and throughout were much healthier than the others. The temperature of both portions was from time to time noted on sunny days with the following result:

	EARTH COVERED WITH SOOT.		PURE EARTH.	
	Depth, 2 In.	Depth, 8 In.	Depth, 2 In.	Depth, 8 In.
	55.4	52 6	58.0	52.1
	56.9	55.0	55.2	55.4
	67.2	63.9	65.1	60.8
	64.5	63.2	63.8	62.4
	61.7	58.7	58.8	58.0
	63.0	60.6	61.4	59.2
	58.1	56.9	57.2	56.3
	65.4	62.2	63.5	61.8
	63.2	63.8	63.9	62.0
	....	61.4	60.0	60.0
Average..	61.96	59.83	60.19	58.74

From this table it clearly appears that the potatoes grown in dark soil have a warmer climate, so to speak, than those in a light one. The tubers with no soot were weak, and had a great deal of disease among them, while the other lot were nearly all healthy.

Chemical examination showed the prin-

cipal inorganic constituents to be present in both in about the same proportions. There was a marked difference, however, between the two in the development of the starch-granules. In the potatoes grown under soot there was 22.5 per cent. of starch, but in the others only 17.5 per cent. —a difference of 5 per cent. Then, as for the size of the starch-granules in the good potatoes, the average was 0.175 millimetre; but in the diseased tubers it was only 0.155 millimetre. Thus it is seen that not only were the granules smaller, but their number was less. The inference is, that increase of temperature gives a great impetus to the growth of starch-granules both in size and number.

Asymmetry of the Eyes in Flounders.—The *American Naturalist* for December contains a singularly interesting paper by Prof. Alexander Agassiz on flounders, in which the author recounts his observations upon the manner in which the eyes, in that family of fishes, become placed on one side of the body. In five species of flounders he found that the eye on the blind side travels from its original place (symmetrical with the eye of the opposite side) frontward and upward on the blind side, resorbing the tissues in its way, and new tissues forming behind. This movement of translation is followed by a certain amount of torsion of the whole frontal part of the head, which, however, commences only after the eye of the blind side has nearly reached the upper edge of that side, quite a distance in advance of its original position. So far, Agassiz's observations concur, in the main, with the received theory. Further research, however, showed that the process of translation of the eye is not the same in all species of flounders. Having captured specimens about one inch in length, symmetrical and perfectly transparent, of the species *Bascania*, the author noticed after a few days that "one eye, the right, moved its place somewhat toward the upper part of the body, so that when the young fish was laid on its side the upper half of the right eye could be plainly seen, through the perfectly transparent body, to project above the left eye. The right eye (as is the case with the eyes of all flounders), being capable of very extensive vertical movements through an arc of 180°, could thus readily turn to look through the body, above the left eye, and see what was passing on the left side, the right eye being, of course, useless on its own side as long as the fish lay on its side. This slight upward tendency of the right eye was continued in connection with a motion of translation toward the anterior part of the head till the eye, when seen through the body from the left side, was entirely clear of the left eye, and was thus placed somewhat in advance and above it, but still entirely in the rear of the base of the dorsal fin, extending to the end of the snout.

"What was my astonishment on the following day," continues Prof. Agassiz, "on turning over the young flounder on its left side, to find that the right eye had actually sunk into the tissues of the head, penetrating into the space between the base of the dorsal fin and the frontal bone to such an extent that the tissues adjoining the orbit had slowly closed over a part of the eye, leaving only a small elliptical opening smaller than the pupil, through which the right eye could look when the fish was swimming vertically! On the following day the eye had pushed its way still farther through, so that a small opening now appeared opposite it on the left side, through which the right eye could now see directly, the original opening on the right side being almost entirely closed. Soon after, this new opening on the left increased gradually in size, the right eye pushing its way more and more to the surface, and finally looking outward on the left side with as much freedom as the eye originally on the left, the opening of the right side having permanently closed."

Destruction of Birds in the United States.—In the course of an article in the *Penn Monthly* on the decrease of birds in the United States, Mr. J. A. Allen says of the heron that, though nearly useless as food, it has been enormously diminished in numbers, mostly through natural causes, but in part by the wanton act of man. "Many," he writes, "have of late been destroyed for their feathers in Florida especially; the havoc made with these poor defenseless birds is a subject of painful contemplation

and a disgrace to the age. The poor birds are attacked at their breeding-grounds, and hundreds are slain in a few hours by single parties, whose only use of them is to secure the beautiful plumes with which Nature has unfortunately adorned them. In this way colony after colony is broken up, the greater part of the birds being actually killed on the spot, often leaving nestlings to suffer a lingering death by starvation. The few old birds that survive usually abandon the locality where for generations their progenitors had lived and reared their young undisturbed, only to be attacked at some new point the following year. The habit most of the species of herons have of breeding together in communities renders their destruction during nesting-time an easy matter, their strong parental affection leading them to be neglectful of their own safety when their young are in danger. Disgraceful and inhuman as the act may seem, many a heronry of the qua-bird, or night-heron, is annually destroyed in mere wantonness, in order that the perpetrator may boast of the 'cart-load' of birds he shot in a single day!"

The Plasticity of Ice. — Experiments made in 1871 by Prof. Bianconi, of Bologna, showed that slow changes of form in ice may be produced without any crushing or regelation, and that ice is, to a certain extent, plastic. He has lately published the results of further experiments on this subject, a brief notice of which is given in *Nature* as follows: "Granite pebbles and iron plates are slowly pressed into ice at the same temperatures, and not only do they penetrate into it as they would penetrate into a fluid or semi-fluid, but also the particles of ice are laterally repulsed from beneath the intruding body, and form around it a rising fringe. Moreover, when a flat piece of iron is pressed into the ice, the fringe rising around it expands laterally upon the borders of the piece, and tends thus, as in fluids, to fill up the cavity made by the body driven in. These experiments tend greatly to illustrate the plasticity of ice, but it would be very desirable that some measurements should be given, so as to obtain numerical values of the plasticity of ice under various circumstances."

Perils of Arctic Exploration.—Lieutenant Payer, one of the commanders of the Austrian Polar Expedition of 1872–'74, in his published narrative gives a graphic account of the perilous situation in which the expedition found itself on Sunday, October 13, 1872. "In the morning of that day," he writes, "as we sat at breakfast, our floe burst across immediately under the ship. Rushing on deck, we discovered that we were surrounded and squeezed by the ice; the after-part of the ship was already nipped and pressed, and the rudder, which was the first to encounter its assault, shook and groaned; but, as its great weight did not admit of its being shipped, we were content to lash it firmly. We next sprang on the ice, the tossing, tremulous motion of which literally filled the air with noises as of shrieks and howls, and we quietly got on board all the materials which were lying on the floe, and bound the fissures of the ice hastily together by ice-anchors and cables, filling them up with snow, in the hope that frost would complete our work, though we felt that a single heave might shatter our labors. . . . Mountains threateningly reared themselves from out the level fields of ice, and the low groan which issued from its depths grew into a deep, rumbling sound, and at last rose into a furious howl as of myriads of voices. Noise and confusion reigned supreme, and step by step destruction drew nigh in the crashing together of the fields of ice. Our floe was now crushed, and its blocks, piled up into mountains, drove hither and thither. Here they towered fathoms high above the ship; there masses of ice fell down as into an abyss under the ship, to be ingulfed in the rushing waters, so that the quantity of ice beneath the ship was continually increased, and at last it began to raise her quite above the level of the sea."

The Coal and Iron Resources of Alabama.—The coal and iron resources of Alabama were the subject of a recent interesting communication by Mr. William Gesner to the Academy of Natural Sciences of Philadelphia. According to the author, the coal-measures of the Warrior and Cahawba coal-fields consist severally of 172 and 173 strata. The coal-seams, which range from

one inch to six feet six inches in thickness, number 46 in the Warrior and 51 in the Cahawba field. Two beds of black-band ore characterize the Warrior measures, one of them showing 43 per cent. of metallic iron; clay iron-stone is abundant, and is found in all the Alabama coal-fields. In one instance it forms the roof of a 28-inch bed of coal in the Warrior measures. Immediately under the mountain limestone of the carboniferous formation in the Upper Silurian, a bed of fossiliferous hematite occurs. It extends in a northern direction over 120 miles into Tennessee. In Jefferson County, Alabama, its thickness is 28 feet. About two or three miles east and west of this ore-bed lie the coal-fields. For its entire extent throughout the State, and immediately under it, are the limestones of the Silurian formation, among which are many of the purest and those best adapted for fluxing iron from its ores. Geologically, in descending order, next come the immense beds of brown ore, comprising manganiferous and fibrous limonite and mamillary and crystallized hematite, from which hitherto nearly all of the iron of Alabama has been produced.

The Physical Properties of Gallium.—The physical properties of gallium, as ascertained by its discoverer, Lecoq de Boisbaudran, who has prepared a decigramme of nearly pure metal, are summed up as follows in the *American Journal of Science:* Its fusing-point is about 29.5 Cent., so that the heat of the hand liquefies it. When liquid, it exhibits the phenomena of surfusion to a remarkable degree. It has remained liquid for more than a month, the globule being frequently broken and reunited by a steel blade in a room the temperature of which often fell below the freezing-point. Contact with a bit of solid gallium, however, solidified it at once. Liquid gallium is very mobile, appears covered with a pellicle when exposed to the air, and adheres strongly to glass. Only a few degrees below its fusing-point the metal is hard and remarkably tenacious; but, like aluminum, it may be cut with a knife. It crystallizes with facility, crystal facets being developed by treatment with hydrochloric acid. It does not oxidize at a red heat except upon the surface, and does not volatilize. Its spark-spectrum gives the two well-known bright lines of wave-length 417 and 403.1; its flame-spectrum only the 417 line, and this difficultly. Its density approximately is 4.7, thus placing it, like its other physical properties, between aluminum and indium. Its atomic weight places it there probably also.

Death of Karl Ernst von Baer.—The eminent Russian zoölogist, Karl Ernst von Baer, died at Dorpat, November 28th, in the eighty-fifth year of his age. He was born at Piep, in Esthonia, in 1792; at the age of eighteen he entered the University of Dorpat, graduating four years later as doctor of medicine. He then went to Germany, and, at Würzburg, became a pupil of Döllinger, the eminent professor of physiology and anatomy. This was the turning-point in Von Baer's career, and determined the course of his future studies. In 1817 he became prosector at Königsberg, and, four years later, professor of zoölogy. In 1830 he returned home, having been elected a member of the St. Petersburg Imperial Academy. He conducted a scientific exploration of the northern shores of Russia in 1837. Of his most celebrated work, "The Development History of Animals," the first volume appeared in 1828 and the second ten years later. He was also the author of numerous treatises on the zoölogy and botany of Russia. His latest work was an adverse criticism on the Darwinian theory.

THE death of Alexander Bain, which took place at Glasgow, January 2d, was cabled to this country, and at once interpreted as applying to the eminent Professor of Logic in Aberdeen University, who bears that name, and who is much more widely known here than Alexander Bain, the electrician, to whom the dispatch referred. He was an inventor, and made various important improvements in telegraphy. He invented, or reinvented, the method of making use of "bodies of natural waters to complete the electric circuit by laying a single insulated wire between the given stations, having at each end a metallic brush immersed in the water." This principle was promulgated in a patent of 1841. In 1846 he patented the electro-

chemical telegraph, and soon found his system capable of great speed; he was thus led to the invention of automatic methods of transmitting signals, of which one is the basis of the most important process now used. He invented electrical clocks, and in 1843 constructed the earth-battery. In 1844 he patented ingenious apparatus for registering the progress of ships, and he also devised electrical methods of playing keyed instruments at a distance. He was struck down with paralysis some years ago, and died, at the age of sixty-six, in a "Home for Incurables." A Government pension of eighty pounds a year was all that saved him from pauperism.

NOTES.

MR. SETH GREEN, of Rochester, Fisheries Commissioner, announces that he is ready to supply brook and salmon trout to persons who desire the same for the purpose of restocking the waters of the State of New York. Applicants must remit to Mr. Green money to pay the traveling expenses of a messenger, and full directions as to the route to be taken.

BENJAMIN R. TUCKER, of New Bedford, Massachusetts, proposes to issue, early in the present year, the first number of a quarterly periodical, to be known as the *Radical Review*, and modeled after the *Fortnightly* and the *Contemporary Review* of London. The list of contributors includes the names of many of the foremost American radicals. The subscription price will be $5 per annum.

IN an address before the Illinois Wool-Growers' Association, Mr. George Lawrence, Jr., of Wisconsin, asserted that merino sheep, taken from Vermont to Wisconsin, show a marked improvement in many respects when bred in the latter State. They have a larger carcass, are heavier boned, quality and quantity of fleece are equal if not superior, and they are more hardy, than their Vermont ancestors.

THE Bulgarian Turk of the lower class believes that a railway-engine is driven, not by steam-power, but by a devil. A young devil is trapped in England, shut up in the "fire-box on wheels," and bribed to work the crank by the occasional gift of a little cold water to mitigate his torture.

M. DROUYN DE LHUYS, President of the French Agricultural Society, has issued a circular to similar bodies in foreign countries, announcing that the society intends to organize an International Agricultural Congress to assemble at Paris during the Exposition of 1878.

THE award of the London Royal Society's medals for 1876 was as follows: To Claude Bernard, the Copley Medal for physiological researches; a Royal Medal to William Froude, for researches on the behavior of ships; Royal Medal to Sir C. Wyville Thomson, for services on board the Challenger; Rumford Medal to P. J. C. Janssen, for researches in the radiation and absorption of light.

PROF. OSBORNE REYNOLDS, in reply to some newspapers which have pronounced the British Arctic Expedition a failure, calls attention to the fact that, since Hudson's time, arctic navigators had penetrated 60 or 70 miles of the 540 to be passed on the route to the pole. But Captain Nares has in one year carried the British flag 60 miles nearer, so that "nearly one-half, and this by far the most difficult half, of the entire results of all expeditions since Hudson's time, has been accomplished by the last." Further, Captain (now Sir George) Nares seems to have pursued his journey to its end, at least by that route; and in coming back can say that he did not leave a single uncertainty behind him.

A VERY valuable mine of silver has recently been discovered at Harbor Island, Newfoundland, near the public wharf.

AN act of the Parliament of the Dominion of Canada grants an additional quarter-section of land, on payment of a trifling fee, to every settler on Dominion lands who plants with trees thirty-two acres in successive annual installments.

DR. A. E. FOOTE has established at 3725 Lancaster Avenue, Philadelphia, an agency for the sale and exchange of natural-history specimens, including minerals, botanical and zoölogical forms, fossils, prehistoric relics, etc. He issues a monthly bulletin containing the needed particulars, and which may be obtained on application.

AN eminent scientific professor, interested in the state of science-education in our colleges, has been looking into the subjects of their use of text-books. He collected catalogues from 187 colleges, and gleaned from them the following statistics regarding the physical and chemical text-books employed. For physics, the text-books ran thus: Olmsted in 48 colleges, Ganot in 33, Silliman in 16, Steele in 15, Deschanel in 12, Rolfe and Gillette in 11, Wells in 8, Norton in 8; the others scattering. The preferences for chemistry ran as follows: Youmans in 37 colleges, Eliot and Storer in 28, Barker in 24, Roscoe in 18, Steele in 18, Fownes in 13, Wells in 10; others scattering.

A TAME crow, in the possession of a writer in the *Nuttall Ornithological Club Bulletin*, rids himself of parasites in a very ingenious way. He takes his stand on an ant-hill, and permits the ants to crawl over him and carry away the troublesome vermin. The same habit was observed in another tame crow formerly in the author's possession.

DIED in Indianapolis, December 12, 1876, Prof. Herbert E. Copeland, aged twenty-seven years. His scientific studies were commenced at Cornell University, where he devoted himself chiefly to natural history, graduating Ph. B. in 1872. He then became, successively, principal of an academy at Ravenswood, Illinois, and Professor of Natural Sciences in the normal school at Whitewater Wisconsin, and in the high-school at Indianapolis. His premature death was the result of exposure while studying the ichthyology of the State of Indiana in company with Prof. Jordan.

IT is proposed in California to establish at numerous points in the State experiment-stations for the purpose of accurately determining sundry agricultural problems, such as the nature of the soils of different localities, the best mode of maintaining and restoring productiveness, etc.

A FEARFUL epizoötic prevailed last fall among the horses of Egypt. On the 18th of September 200 horses died in Cairo alone. The army-horses were specially afflicted, and 50 per cent. of them had died before the end of September. The carcasses were transported into the desert and thrown into those enormous bone-quarries of which we can have no idea here. But many were cast into the canals, and the consequences may be disastrous. It is supposed that this equine plague came from Abyssinia.

PROF. LEIDY, in dredging the bottom of the Schuylkill near its mouth, was surprised to observe that no living thing whatever was brought up, the mud and sand being black and saturated with bituminous oil. The refuse of the city gas-works and probably of some coal-oil refineries run into the river. The oils appear to have an affinity for the suspended particles of clay, and the result is a bituminous sediment. In the same manner oils from decomposing animals, and also from certain plants, may have supplied the sedimentary muds of ancient shales.

A RADIOMETER, in the shop of a Paris optician, during the first two weeks of December, twice stopped entirely in the daytime —viz., on the 8th, during a thunder-storm, and on the 13th, during a fog. The instrument varied considerably as to the moment of daily commencing to revolve—the extremes being 8.15 and 10.25 A. M. The time of stopping was far less irregular—the variation being only from 3.30 to 4 P. M.

MOST of the monthly educational journals in the Western States have been consolidated to form one strong weekly—the *National Journal of Education*, published in Chicago. The editors are W. F. Phelps, editor-in-chief, Prof. E. Olney, and others. Special editors will be employed to conduct special departments. The subscription price of the *Journal* is $2.50 per year.

IN the hope of eliciting further information concerning the breeding-habits of the American kinglets (*Regulus*), or at least of putting observers upon the alert for further information, Mr. Ernest Ingersoll publishes, in the November number of the *Bulletin of the Nuttall Ornithological Club*, a paper in which is brought together whatever is at present known respecting the nidification of these birds.

IN consequence of the extraordinary precautions taken last Fourth of July, the losses by fire from the use of fire-works were less than usual on that anniversary; but the losses so caused were nevertheless enormous. In the report of the National Board of Underwriters it is stated that the invoice value of all fire-crackers imported since January 1, 1875, is less than $1,500,000, and that the loss by two conflagrations traceable directly to them amounts to upward of $15,000,000! It is considered to be not an extravagant statement that every dollar's worth of fire-crackers imported into this country occasions a direct loss by fire of more than $100.

IN order to reduce to the minimum the danger to health incurred by workmen employed in the manufacture of white-lead, the British Inspector of Factories recommends that clothes, gloves, and caps, should be provided for the employés to be worn in the works; water-proof boots for those working with the moist white-lead, and respirators for those working with the dry white-lead. Besides, no workman should be allowed to leave the works unwashed, or in the factory-dress.

THERE appears to be at present a considerable degree of religious fermentation in Russia, and sects of all kinds are daily springing up. One of these new sects, the Philipovtzi preach suicide by fire and starvation as the greatest of Christian virtues. The "Child-Murderers" think it their duty to people paradise with the souls of innocent children. The "Stranglers" believe that people can only enter paradise by a violent death. Other sects are the "Flagellants" and the "Skoptzi," or mutilates. The Skoptzi number about 100,000 persons of both sexes.

WILLIAM CROOKES, F.R.S.